Jos. S. Henry

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PAPERS

ERRATUM.

On page 6, line 12, "as Mr. John Burns, the father of the British Town Planning Act, observes"; should read, "as Mr. A. T. Edwards observes".

Paper No. 50

CITY PLANNING.

By

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WHAT CITY PLANNING IS.

The attention lately given to the subject of City Planning all over the world indicates that it is one in which the people generally are interested; not only those living in large cities, which may undertake costly and pretentious schemes of improvement, but the dwellers in the small towns, and even villages, all of whom are eager for information upon the subject and are ready to devote their time and energy to the study of plans to make their communities more orderly and attractive. Conferences and exhibits are frequent and largely attended whether in Europe or in America. Books and magazine articles upon the subject appear at short intervals, and one quarterly publication is devoted exclusively to the subject of "Town Planning". A majority of the writers, speakers and exhibitors are architects, landscape architects, social workers or others whose interest in the subject is keen but whose experience is limited. Engineers have not been as active as might be expected and have heretofore seemed disposed to leave city planning work to others. Mr. R. Verstraete, engineer of bridges and roads at Bruges, has described the attitude of the engineer in the following words:

"Throughout all ages, mankind has done its utmost for the embellishment of cities. The remains handed down to us from antiquity and from the Middle Ages testify as to this point. Few works, however, appear to have been written on the subject, and of these the most important are of comparatively recent date. They are mostly the works of art enthusiasts. En-

gineers appear to take little interest in the subject. If their apparent indifference continues much longer, they will find that this natural branch of their profession will pass into other hands, which would be much to be regretted. The dominating desire for the picturesque, for variety and for originality which ever guides art enthusiasts will never lead to the possibility of a natural solution of a problem such as is the outcome of utility linked with good taste".*

Notwithstanding all that has been said and written upon this subject, there seems to be more or less uncertainty as to just what City or Town Planning means. Some appear to consider it the designing of spectacular effects in the grouping of public buildings and the establishment of civic centers, the creation of imposing open spaces, the cutting through of broad avenues or the straightening and widening of existing streets, the reorganization and rearrangement of transit facilities and terminals; in short, the rebuilding or making over of cities and towns. These might more properly be called the correction of mistakes or the remedying of defects due to a lack of proper planning rather than the more fundamental work of city planning which should have as its chief object the avoidance of the necessity of costly reconstruction. What then is City Planning? Many definitions have been written, some long and some short; some emphasizing the architectural and artistic side and others laying chief stress upon its social aspects, but few of them appear to recognize it as an engineering problem.

Mr. George McAneny, President of the Board of Aldermen of New York City, who is not only a close student of municipal problems but has had unusual experience as a city officer, says:

"City Planning simply means getting ready for the future in city growth. It is the guidance into proper channels of a community's impulses towards a larger and broader life. On the face it has to do with things physical,—the laying out of streets and parks and rapid transit lines, but its real significance is far deeper. A proper city plan has a powerful influence for good upon the mental and moral development of the

* Proceedings of Third International Road Congress, London, 1913, Paper No. 3.

people. It is the firm base for the building of a healthy and happy community''.

Other definitions might be quoted, definitions of architects, landscape architects, artists, lawyers, publicists, but few engineers have stated what they understand city planning to be. The definition of the author, first used in a paper before the Municipal Engineers of the City of New York in 1911, is this:

''City Planning is simply the exercise of such foresight as will promote the orderly and sightly development of a city and its environs along rational lines, with due regard for health, amenity and convenience, and for its commercial and industrial advancement''.*

There seems to be a general disposition on the part of most people to attribute peculiar merit to the planning of the cities in other countries. The English, for instance, greatly admire the wide streets and the effective grouping of buildings in German cities, while the Germans are charmed with the garden villages attached to some of the great manufacturing plants in England. American writers on city planning have been extravagant in their praise of the planning and arrangement of old world cities and are constantly comparing them with their own towns to the great disadvantage of the latter. This tendency is scarcely due to national modesty but is probably attributable to an almost universal disposition to be attracted by and to admire effects with which one is unfamiliar, provided they do not too violently offend certain customs and standards which are so ingrained as to have become habits.

The achievements and salient points of city planning in various countries show different characteristics. These have been well expressed by Professor Patrick Abercrombie in an interesting article in the ''Town Planning Review'', a few paragraphs of which will be briefly abstracted.†

Sweden was perhaps the first country to enact a comprehensive town planning law, which appears to be based upon the assumption that a plan is requisite for every town. The

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* ''The City Plan and What It Is'', Proceedings of Municipal Engineers of the City of New York for 1911.

† See Town Planning Review, Volume IV, No. 2, Page 98.

results obtained from the application of this act may be subject to the criticism that insistence upon wide streets and extreme regularity has tended towards a monotonous gridiron plan which in some cases has been forced upon the old and irregular parts of the cities.

Germany has perhaps achieved more modern town planning than any other country and yet if judged by legislation, the German cities appear to possess very limited powers, but in Germany city planning is a tradition and its desirability is never questioned. Conspicuous features of German planning are the zoning system by which the erection of lofty tenements has been restricted; the practice of converting old fortifications into wide circumferential streets as in Bremen and Cologne; the careful preservation of the ancient centers of the city as in Frankfort and Nuremburg; the acquisition of large tracts of land outside the city, which in Strassburg is said to be equivalent to a plot 57 ft. square to each inhabitant, in Ulm to 80% of the total area of the city and its immediate suburbs, and in Berlin to three times the area of the city itself. The "Lex Adickes" gives the municipal authorities power to redistribute land which as originally divided may have been rendered practically useless by the adoption of a street system, the land remaining after providing for streets and open spaces, being redistributed in usable portions. This law, which appears to meet a situation the difficulty of which has long been recognized in other countries, was devised by and bears the name of a distinguished municipal officer who was for many years the Mayor of Frankfort.

Austria is essentially German in its treatment of city planning problems; but Vienna, the Austrian capital, is a city in its own class. Its Ringstrasse on the line of the inner fortifications is one of the most notable streets of the world. A second ring street has been provided on the lines of the outer fortifications, while there is again a ring of meadow and beyond that a girdle of wooded hills.

France has paid more attention to the physical construction of its cities than to their organization, and has laid more stress upon the monumental and architectural aspects of the street plan than upon picturesque effects. No city has pro-

vided as well as Paris for direct exits from and approaches to the city, although several of her great boulevards were originally constructed as private drives for royalty. Perhaps the Avenue de l'Opera is one of the most notable achievements of city planning by the construction of a new street furnishing an impressive vista. Traffic planning has claimed a large share of the attention of students of city planning in France.

England has been somewhat backward in what may be called the monumental aspects of city planning. Scarcely a single great building has been provided with an adequate site and approach in modern times, while failure to provide for traffic needs has been most conspicuous, and yet it is the English individual home which has been religiously protected for generations, which appears to be the moving spirit in most of the town planning of the last decade.

In Belgium the strong individuality of the different towns, —Brussels, Antwerp, Ghent and Bruges—is conspicuous. Recent plans for the improvement of Brussels, however, appear to have derived their inspiration from Paris.

Italy has not been behind her neighboring countries in city planning or in legislation directed to that end. The Italian cities possess powers of exappropriation which have been found to be exceedingly valuable and these powers have been exercised in a wise fashion, enabling the authorities to recoup a large proportion of the cost of public works.

In the South American cities of Rio de Janeiro and Buenos Aires some ambitious projects have been carried out, particularly the cutting through of new streets and the creation of great boulevards along the water front which have made these cities among the most notable in the world.

In the United States three conspicuous features of city planning are emphasized in the article referred to: first, the prevalent devotion to the gridiron plan which is described as "a scientific nightmare in which squares are carried over the whole country, irrespective of natural zones and contours and in comparison with which the lack of planning which formerly prevailed in England is admirable"; second, the great number of monumental projects which have lately been put forward, many of them most imposing and beautiful, while traffic

improvements have been conspicuously successful; third, the scientific provision for recreation which has lately been made in many American cities.

While it is interesting to note the characteristics of city planning in various countries as interpreted by students of the subject, it must not be forgotten that the fundamental principles underlying the planning of all cities are practically the same, although the method of their expression may differ. Such method may be the result of habit or of local tradition rather than of painstaking investigation, and it is frequently admired because it is somewhat different from that to which we are accustomed; but, as Mr. John Burns, the father of the British Town Planning Act, observes, "While there is town planning in England, town planning in Germany, town planning in France, there is no such thing as English, German or French town planning any more than there are English, German or French sciences of arithmetic".

Perhaps it may fairly be said that the city planning which is now being done in the United States is chiefly confined to projects covering very restricted areas, the designs for which are usually made by a single man or a small group of men, architects, landscape architects, and occasionally engineers being associated together. The gradual development of a beautiful city, like some of the old towns of Europe, from the painstaking work of many individuals of successive generations, all of whom had an intense pride in their city, is practically unknown. A desire to do the work well rather than quickly or cheaply seems to have given place to the ambition on the part of temporary office holders to carry out particular improvements during their terms of office or in such a manner that they will, it is fancied, be forever identified with their names. Whether or not a particular improvement will fit into a comprehensive scheme of development is a matter of indifference to them.

There is a conspicuous lack of originality in many of the city planning schemes which are constantly being advocated. The designers are too prone to attempt the reproduction of some public square or "grand place" which may arouse well merited admiration in the town in which it is located, but which may be entirely incongruous in a modern American city.

An attempt to transplant a picturesque bit of Rothenburg to the plains of Long Island or to the prairies of the Mississippi Valley would be absurd; a Venetian "piazza" in Pittsburgh or Omaha would be grotesque. "Don't copy Europe", is the advice given to American city planners by no less an authority than Dr. Werner Hegeman of Berlin. A rational city plan is inevitably of slow growth and, while there seems to be a pasionate desire at the present time to correct at once such obvious defects as are to be found in the plans of most of the cities of Great Britain and the United States, and from which those of continental Europe are by no means free, the task is too great for any one man or group of men or even for any one generation, and there is danger that, recognizing the futility of the attempt and staggered by the magnitude of the undertaking, interest will be lost and we will go on repeating our old mistakes. As Professor Eberstadt says, "Town planning rushed at too hurriedly or pursued unadvisedly may turn out to be an instrument of greater danger than a mere leaving to chance the growth of our cities".

The city planning movement, as it is now generally understood in America, may be said to date from 1893 when the "white city" created by the genius of the late Daniel H. Burnham and an able group of associates for the International Exposition held that year in Chicago made a profound impression upon all who saw it. It is safe to say that such effective grouping of a series of monumental buildings of harmonious design had never before been accomplished or even attempted and, while the buildings themselves were temporary, the effect which they produced has been permanent and the influence of the general plan is quite evident in most of the ambitious projects for the creation of civic centers which have since been put forward. The British, who have developed great enthusiasm over town planning, appear to have acquired a more fundamental conception of what planning means in that they are devoting their attention chiefly to the territory not yet developed, in an effort to avoid such blunders as have been made in the past, rather than to try and make their towns over or, when that is found to be impossible, to create one or two beauty spots or show places.

There are many who believe that the chief purposes of city planning are social, that problems of housing, the provision of recreation and amusement for the people, the control and even the ownership and operation of public utilities, the establishment and conduct of public markets, the collection and disposal of wastes, the protection of public health, the building of hospitals, the care of paupers, criminals and the insane, and all of the other activities of the modern city, are a part of city planning. These, however, are matters of administration rather than of planning in the sense in which it will be considered in this paper, and the author's intent is to refer to them only as they are related to the more fundamental problems of so planning a city that the necessary buildings or the space required for them may be provided without the destruction of improvements already made or a recasting of the plan, so that good sanitation and decent housing and all that makes a city a better place to live in will be made easy rather than difficult.

THE ELEMENTS OF A CITY PLAN.

Few writers on city planning have defined the elements of a comprehensive city plan. Some of those doing so have laid special emphasis upon the organization and administration of the city, particularly its social activities, and their list is a long one. Others have defined the several districts or quarters of a city which require special treatment, and their list is shorter. An American architect has given twelve heads under which significant facts should be collected and classified in a study of city planning, namely, streets, transportation of people, transportation of goods, factories and warehouses, food supply and markets, water supply and sanitation, housing, recreation parks, boulevards and street planting, architecture, laws, financing.* A French writer gives four divisions of the city which require special study and treatment: the business, the industrial, the administrative, and the residential quarters.† He also notes that "the climatic conditions of each

* Mr. George B. Ford in a paper on "The City Scientific" presented at the National Conference on City Planning, Chicago, 1913.

† Mr. A. Agustin Rey in a paper on "The Growth and Development of Towns" presented at the London Town Planning Conference, 1909.

country must necessarily determine the type of dwellings selected by the inhabitants''. He might have added that the same conditions affect the position of dwellings and other buildings with respect to each other, the width of streets, and various other features of the city plan.

Without regard to the various municipal activities and administrative details, the convenience and attractiveness of a city will depend upon four features of its plan:

1. The transportation system, or the means provided for getting in and out of the city, and for quick movement of passengers and freight from one part of the town to another. It is obvious that transit needs cannot be accurately foreseen, but provision should be made for improving and extending them when needed. A large part of the transportation will always be in the streets themselves, and its adequacy and efficiency will be largely determined by the location and dimensions of the streets in which the intra-urban transit lines are located.

2. The street system in and through which the daily business is done and by which the people gain access to their homes and pass from these homes to their work, recreation and amusement. A street system once adopted and developed must remain indefinitely. While some streets may be widened and an occasional new street may be cut through existing improvements, the general street plan, once established and constructed, is fastened upon the city as long as the city itself lasts. A catastrophe such as the great fire of London in 1666 or the San Francisco fire in 1906 may afford an opportunity for a recasting of the plan for a considerable area, but it is seldom availed of.

3. The park and recreation facilities upon which the comfort and health of the community are to a large degree dependent. It is true that a lack of proper parks may be supplied at any time, even when the space to be devoted to that purpose shall have been built upon and when the cost of their acquisition will be greatly enhanced, but a park system can be most economically and satisfactorily established in advance of other improvements and facility of access to them and proper connections between the different park units will de-

pend upon the street system, so that the park plan should be worked out in connection with the street plan.

4. The location of public buildings, which may render the conduct of public business convenient or difficult and may give a favorable or unfavorable impression to visitors. Public buildings like business buildings can be changed in location as necessity and convenience may require, but the suitability of their sites, whether they are convenient and commanding or awkward and unprepossessing, will depend upon the streets about them and leading to them, so that the location of these buildings should receive the most careful study in the preparation of the general plan of the city.

While there may be other elements which go to make up the complex organism called the modern city, those enumerated are the ones which are likely to give the town its character, to make it convenient or inconvenient, dignified or commonplace. Upon the skill and foresight exercised in providing for them will depend to a large degree the orderliness of the city's growth, and the facility with which individual and corporate activities can be carried on. These four features of a city plan will be discussed in some detail in the order in which they have been named.

THE TRANSPORTATION SYSTEM.

The modern city owes, in most cases its genesis, and in all cases its growth and prosperity to its facilities for internal communication and for easy access to its sources of supply and to markets for the disposal of its manufactured products. While this is conspicuously the case with industrial towns, it is true with respect to all great centers of population. The fullest consideration should, therefore, be given to the general problem of transportation in the original planning of a city, but the most that can be accomplished by such study will be to render it possible to provide for the expansion of transit facilities as required with a minimum of disturbance of the general city plan. If due provision shall have been made for getting passengers and goods into and out of the city, manufactories and general business will be attracted and population will in-

crease, and as the city grows the problems of internal communication must be solved.

As business increases, the central portions of the town will be given over to it, the land will become too valuable for residential use and those who have had their homes in these districts will move further out. The workmen who find employment in the mills and shops will, unless proper houses are provided for them in the vicinity of their work, go as far as the time consumed and the rate of fare will permit in order to secure decent homes for their families on terms that they can afford to pay as home owners or tenants. The results of such shifting of population, while presenting some serious problems, are beneficial. In the report of the London Traffic Branch of the Board of Trade for 1913, it is stated that "No one can doubt the benefit conferred upon the community by the migration of population which has taken place and is still in progress from the central area to the healthier and happier surroundings on the outskirts, and this beneficial progress can best be stimulated by the provision of such additional travelling facilities as will enable new and more distant areas to be opened up for building". Ample facilities to enter and leave a city are as important as those for inter-communication between the different parts of the same city. In a paper presented to the City Planning Conference in Chicago in 1913, Mr. Milo R. Maltbie points out that the city which has the best transportation facilities by land and water is the one which will increase most rapidly and that "the city which has the cheapest, most rapid, and most convenient facilities for communication between its various parts is the city, other things being equal, which has the most productive and healthful citizenship". The districts immediately adjacent to railroads are not usually attractive and they are commonly more shabby and unsightly than they need be. They are naturally adapted to manufacturing, but they are too frequently given over to the poorer classes of houses. Mr. Edward H. Bennett expresses the opinion that "where many railroads radiate from the city in different directions, the triangular shaped areas lying between them for a considerable distance out from the center of the city are reduced to a low level of utility, even

though they have comparatively high values in the real estate market, and in these pockets are found the worst tenements and slums''. If the general ground plan of a city has been laid out with due regard for the entry into it of trunk line railroads with ample terminal facilities and for such connecting lines as will provide for the economical and expeditious handling of freight, and with spurs to serve industrial plants, and if the waterfront has been so planned as to provide for convenience of shipping and for ready inter-communication between rail and water traffic, those facilities will be provided as the demand for them grows with a minimum of expense and disturbance of ordinary business.

Seaport cities have been slow to appreciate the need of the proper correlation, if not the unification, of rail and water terminals. They appear to have proceeded under the idea that the material brought into the city is for home consumption or is to be transformed into manufactured products before it is trans-shipped to internal points, and have not appreciated the importance of their functions as distributing centers. Railroad terminals are often planned as if there were no other means of transportation. Shipping terminals are likewise designed as though railroad connections were of little or no importance. Only recently has the problem of port organization attracted the attention which it deserves.

The transportation problem of cities is to be treated as a separate subject and will be referred to in this paper only in its relation to fundamental city planning. In this connection too much emphasis cannot be laid upon the need of keeping in mind from the beginning the proper connection of railway lines with each other and with the terminals for water borne traffic. Chicago is suffering from the lack of a unification of the system of trunk line railways centering in the city and is trying to work out a plan which will bring some sort of order out of the confusion which now exists. (Figs. 1 and 2.) New York now appreciates the imperative need of a coordination of its rail and water terminals along the lines which have been followed by such seaport cities as Liverpool, Hamburg, Antwerp and Buenos Aires, and even by inland ports such as Manchester, Duisburg and Frankfort.

Railway and waterfront terminals, though neglected in the original planning of a city, can be provided or enlarged notwithstanding the fact that the general city plan did not contemplate their need, even though the cost of doing so will be very great; but the handicap placed upon the intra-urban

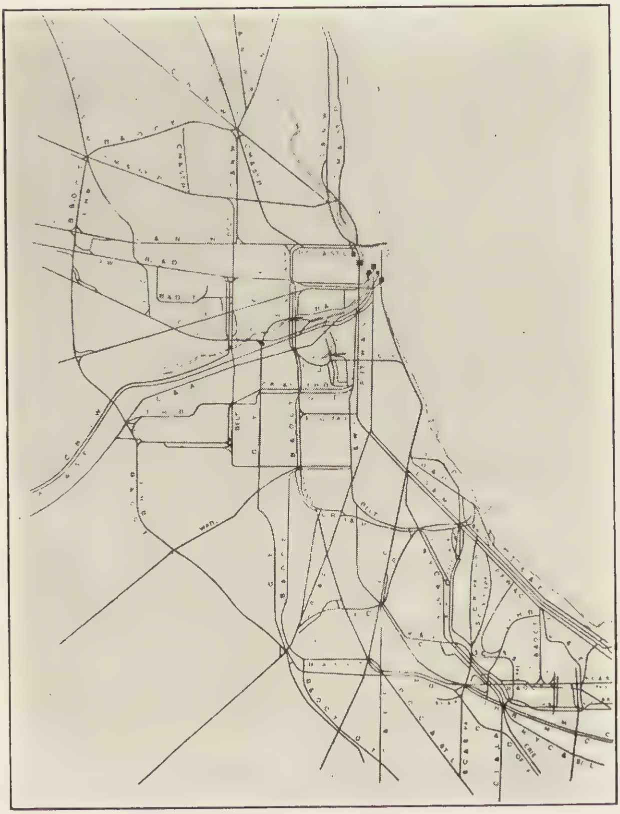

Fig. 1. Plan showing the different railroads entering the city of Chicago, each on its own right of way. Reproduced by permission of The City Club of Chicago from a report made by that body.

transit system through an inadequate and badly arranged street system can never be fully overcome. These transit lines will be in the streets of the city and upon them the great majority of the citizens will depend for their daily trips, whether their purpose be business or pleasure. It is impossible to an-

ticipate just how a city will grow or what transit lines will be required first. It is fair to assume that the transit system will be developed as a unit and not through the construction of competing lines occupying adjoining streets when needed facilities can be furnished by fewer lines more intensively used and under one management.

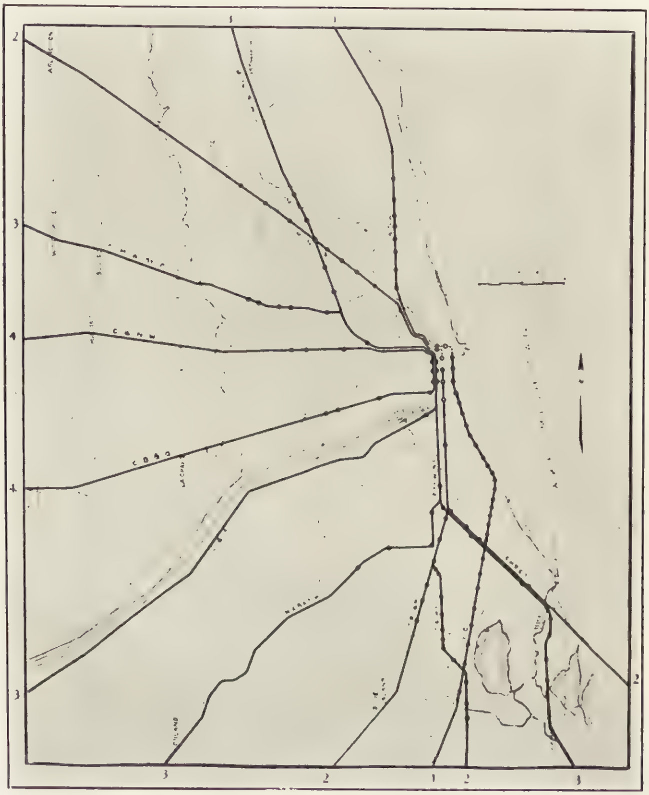

Fig. 2. Plan prepared by Mr. Bion J. Arnold for The City Club of Chicago to simplify the trunk railway system of Chicago, each line being on an existing right of way. Reproduced by permission of The City Club of Chicago.

In great cities elevated and underground railways may be required on certain streets; these, however, will be few and will be confined to the most heavily traveled routes on which the surface lines will have preceded them. A street which will accommodate a double track surface railway and leave

room for vehicles between the cars and the curb will also accommodate a two track underground railway with station platforms. Such roads are sometimes built with three or four tracks but only in very large cities and where there is exceptionally heavy traffic along a few lines. Elevated railroads offer such serious obstruction to light and air and are so noisy and, as commonly constructed, disfigure the streets to such an extent that they will not often be tolerated. An elevated railroad of unusual type and built under exceptional conditions is the three track line now being constructed in Queens Boulevard in New York City. It is composed of a series of arches between piers, which are themselves pierced by arched

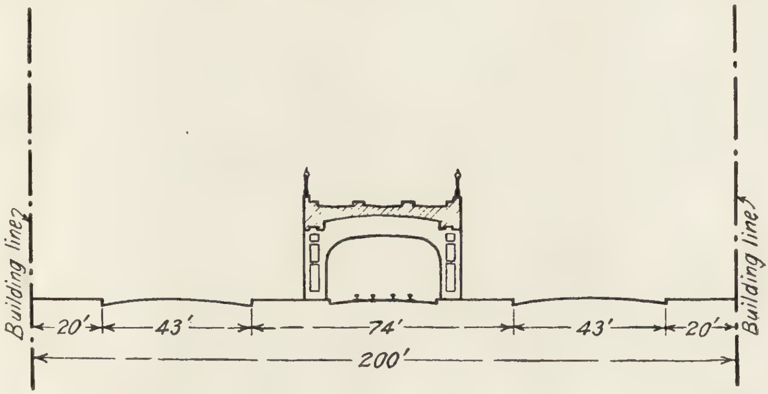

Fig. 3. Cross section of Queens Boulevard, New York City, showing three-track elevated railroad on reinforced concrete structure, with service tracks beneath.

openings designed to accommodate a double track surface railroad. The street is 200 ft. in width, the part in which the elevated railway is located having two roadways each 43 ft. wide, the space between them being 47 ft. in width, allowing room for planting on each side of the elevated structure which is itself 77 ft. from the side lines of the street, so that there is no obstruction to light and air, while with a solid floor, stone ballast, and parapet walls outside the track, the noise will be reduced to a minimum. (Fig. 3.) This is probably the best type of elevated railway yet built within street lines. While streets can rarely have such unusual dimensions, if a few avenues leading directly out from the main centers of large cities were given a width of 150 ft., it would be possible to provide ele-

vated lines of this kind which would be far more agreeable to ride on and would cost much less to build than underground roads. The difficulty and the cost of constructing rapid transit lines in city streets are so great and both are so intensified in narrow streets that the provision of adequate street widths

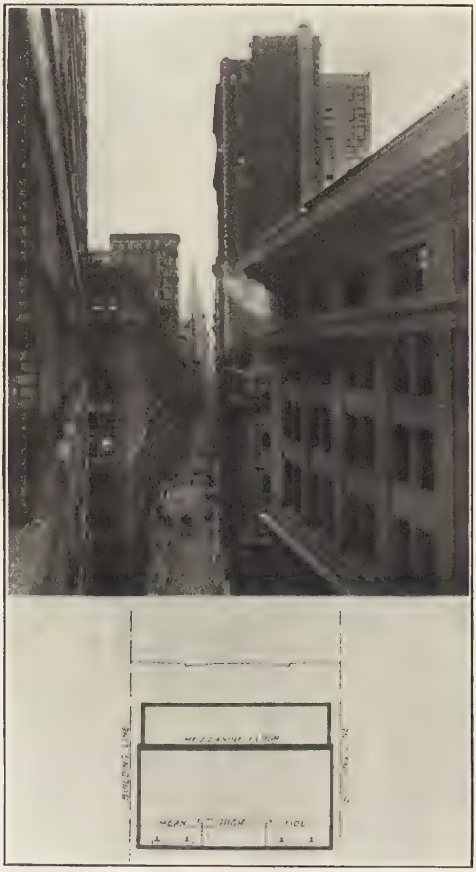

Fig. 4. View of William Street, New York City, and section of the double-track rapid-transit subway being constructed within its lines.

for transit purposes is fully justified. A peculiarly difficult piece of underground railway construction is that about to be undertaken in the building of a double track rapid transit subway in William Street in New York City. This street is but 40 ft. wide between building lines and the subway follows it for

half a mile. It will require an excavation about 29 ft. in width which at stations will be increased to the full width of 40 ft. between the building lines to provide for island platforms from which stairways will extend to a mezzanine passage-way connecting with the stairs leading to the street surface. The depth to subgrade will vary from 25 to 31 ft. below the surface, and in general the excavation will extend from 3 to 5 ft. below high water with a maximum of 14 ft. at Maiden Lane and 20 ft. at Pearl Street below that datum. The estimated cost of this one-half mile of underground railway, based upon the lowest bid for the work is $2,254,670 or about $850 a linear foot of subway, and it would be difficult to find a more forcible illustration of the need of providing in the plan of a city streets whose position will make them available for rapid transit routes and

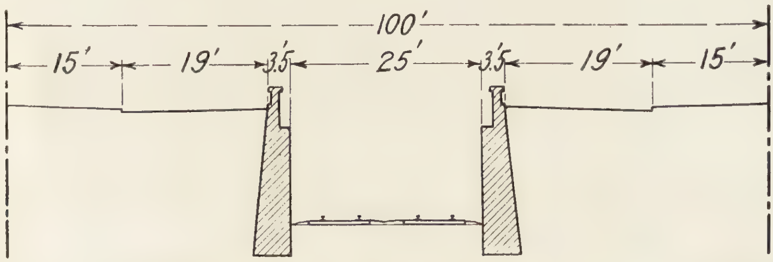

Fig. 5. Showing open cut for rapid-transit railroad with retaining walls in street 100 ft. wide, constructed with a view to converting it into a tunnel, when necessary.

whose width will be sufficient to permit the construction of such lines without an expense which would be prohibitive in most cities. (Fig. 4.)

Where underground railroads will be ultimately required but where they are built in advance of extensive development and before surface traffic is great and where streets are sufficiently wide, they can be built in open cuts which need not be covered until the space above them is required for street purposes. In cases where the street width is sufficient, the sides can be sloped and retaining walls omitted until the tracks are covered or the space occupied by the slopes is needed for additional tracks. (Figs. 5 and 6.)

By far the greatest mileage of railway lines in any city will be the surface tracks in the streets, operated by the over-

head trolley system. The inflexibility of the surface railway in comparison with motor-busses and other free-wheel vehicles necessitates a greater roadway width for their accommodation. Unless there is room for other vehicles to pass between the cars and the curb, congestion will result. A New York City ordinance prohibits the construction of a double track surface railway in any street having a roadway less than 40 ft. between curb lines or a single track railway where the distance between curbs is less than 30 ft. Sidewalk widths should not be unduly curtailed in order to provide space for surface railroads. Double track roads are preferable to single track lines with movement in a single direction. The author believes that any street which is likely to be called upon to accommodate surface railway

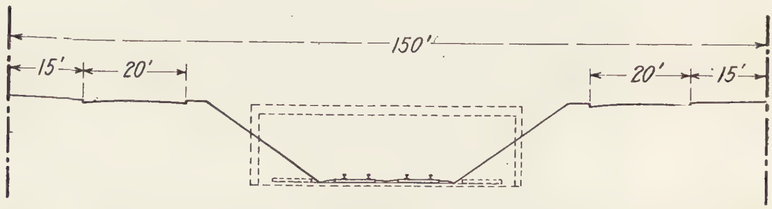

Fig. 6. Showing a double-track rapid-transit railroad with side slopes in a street 150 ft. wide, with a view to converting it into a four-track, underground road, when necessary.

tracks should be given a width of not less than 70 ft., while in the case of main traffic arteries where elevated or underground railways may also be required, such width should in no case be less than 80 ft.

THE STREET SYSTEM.

There have been a few cases where important cities have been planned as a unit; where the administrative center, the commercial, industrial and residential districts, the lines of transportation and their terminals, have been laid out after careful study to meet conditions which could be confidently expected or to a large degree controlled. Washington is one of the most notable instances of such city planning, and so successful was it that, although the plan was made more than a century ago, and while during its rapid growth it was disregarded in some details, more particularly in the location of public buildings, an effort is now being made to return to the original

design of Major l'Enfant. Plans have lately been prepared for a great continental capital city for Australia. In this case, also, a site was selected where there is not even a village street to form a beginning, and an exceedingly interesting plan has been worked out which appears to take advantage of the natural features of the site. Industrial cities such as Gary, Indiana, established by the United States Steel Corporation, or garden cities, such as are so popular in England at the present time, have been planned and built on entirely new sites, but the city planner usually finds that the beginning has already been made, a beginning which may prove a serious handicap or may, though less frequently, be an admirable nucleus for the larger plan. While in planning for the future growth of an already existing city there is a natural and commendable desire to preserve everything that is old, picturesque and of historic interest, to do so will frequently result in obstructing a free movement of the business and traffic of the city. Few cities are fortunate enough to have had as their starting point a New England village green of generous proportions with a few wide highways radiating from it, or to have had the beginning of a town plan like those of Buffalo and Detroit. Some of the cities of continental Europe are built about an ancient chateau or schloss, the home of a prince who, after tiring of war, has devoted his energies to the laying out of a city of which the royal residence should be the center, and the results have been such towns as Karlsruhe or Mannheim. The city may have been built about or under the shadow of a baronial castle with little other purpose than to be near it and under its protection as in the case of Edinburgh or Nuremburg. Most old cities have simply grown with very little planning. Comprehensive plans, where such have been prepared, are of comparatively recent date and have had to adapt themselves as well as might be to the older portions of the towns as they were, and make designs for sections not yet developed conform with the haphazard growth which had already taken place. Plans of such cities, therefore, commonly consist of a number of separate designs more or less unrelated to each other, abutting upon the confused and uneconomic system of streets in the old town which in most cases has persisted as the actual center. In some

instances expansion in all directions was possible, as in London, Paris, Berlin and Brussels; in others, the ancient town was so located that expansion was in a semi-circular form as in the case of Antwerp, or the growth was confined to a single direction as in New York.

The considerations which led to the adoption of the present plan of that part of New York City now known as the Borough of Manhattan are outlined in the report which was filed with that plan in 1811 and which is interesting reading at this time, when the needs of a great city are more clearly understood. When this commission was created in 1807, the population of New York was about 85,600, and the built-up portion of the city extended north to approximately Houston Street on the East Side and Eighth Street and Greenwich Avenue on the West Side. The commission had a prophetic vision of a great city which would occupy Manhattan Island and predicted that in half a century it would have a population of 400,000, a prediction which was more than verified, as in 1860 the population was more than double this estimate, having reached 805,658. One of the first questions considered by the commission was "whether they should confine themselves to rectilinear and rectangular streets, or whether they should adopt some of those supposed improvements by circles, ovals and stars, which certainly embellish a plan whatever may be their effect as to convenience and utility". The conclusion reached by them was that "a city must be composed principally of the habitations of men, and that straight-sided and right-angled houses are the most cheap to build and the most convenient to live in. The effect of these plain and simple reflections was decisive".

Having decided upon a rectangular or gridiron plan as the most desirable, they appeared to conclude that as the traffic of the city would be principally across the island or from river to river, the greatest number of streets or the greatest traffic capacity should be in this direction, and a series of streets 60 ft. in width with intervening blocks 200 ft. wide was laid out in this direction; although realizing that some of these cross streets would be called upon to accommodate a concentrated traffic, approximately every tenth street was given a width of 100 ft. At right angles to these streets and running in straight

lines along the length of the island, a series of avenues was laid out with a width of 100 ft. each and separated by blocks ranging from 650 to 920 ft. in length. The assumption that the principal traffic would be from river to river may have been a natural one when this plan was made, but it is found to have been a serious and costly blunder. The recent growth of the city has far exceeded the wildest dreams of the Commission of 1807, and instead of being chiefly confined to Manhattan Island, it has extended over Long Island, the portion of which now within the limits of the greater city had on July 1, 1914, a population of 2,173,582 as estimated by the Federal Census Bureau. The East River, which doubtless seemed to the early city planners an insuperable barrier to the further extension of the city in that direction, has been practically eliminated by the construction of four great bridges over it and eight railway tracks in tunnel beneath it, while another railway bridge and four more tunnels are under contract and two other tunnels are contemplated. Six tracks have also been carried under the Hudson River to the adjoining state of New Jersey. With the expansion which has taken place in all directions the few north and south avenues are so over-taxed that, notwithstanding the fact that transit lines have been built over four of them on elevated structures and under some of them in subways, the need of additional thoroughfares in this direction is quite apparent, and the almost entire absence of diagonal or radial highways prevents direct access from one side to the other at points above or below. The plan of New York is an excellent illustration of the lack of appreciation on the part even of men of high intelligence and ability, as were members of the Commission whose report has been quoted from, of the great value of a system of radial or diagonal streets affording easy and direct connections between different parts of the city. The l'Enfant plan for Washington had been made some years before this commission undertook its work, but they probably deemed it more or less fanciful or at least as better adapted to the great national capital than to a commercial city such as New York. Yet about a century and a half earlier, after the great fire of London in 1666, both Sir Christopher Wren and Sir John Evelyn made what are said to have been simultaneous and entirely independ-

ent suggestions for the replanning of the streets of the burned district. The conspicuous feature of these two plans is the emphasis placed upon focal points and the direct connections between them. The London authorities failed to grasp their opportunity and take advantage of the suggestions, owing doubtless to the same desire to rebuild their city as quickly as possible, which has always been manifested by American cities after they have been devastated by fire. In the replanning and reconstruction of Paris under Haussmann, this insistence upon some great focal points with a system of thoroughfares radiating from them, the foci being connected by direct lines of special emphasis, and a system of circumferential streets is seen to be the dominant feature. In many continental cities a study of the street plan will show this same arrangement; in some cases symmetrical and clearly defined, in others somewhat less obvious. It is especially apparent in Cologne, Moscow and Vienna. Its advantages are now quite generally appreciated and the cities possessing these ring streets and radials have often been credited with more wise foresight than they have actually shown. For generations, and even for centuries, the older parts have been hemmed in by fortifications which were deemed essential to their safety. Within the walls there was a maze of narrow and frequently squalid streets, congestion was extreme and the sanitary conditions were deplorable. A few highways led out of the city through the walls and into the open country beyond, but these were not designed as arteries of traffic required by and contributing to peaceful commerce; they were rather routes of advance against or retreat before attacking forces, or were designed to facilitate predatory raids into the surrounding country. When peace, rather than war, became a normal condition and the city walls could safely be demolished and the moats filled up, the possibility of converting the space occupied by them into great ring streets or boulevards and their peculiar availability for this purpose became apparent.

But few towns have old walls which they can convert into ring streets, yet the advantages of such streets are so obvious that they are being planned by many of the great cities, some of them at enormous cost for land and buildings, which must be destroyed, with entire disarrangement of the connecting

streets. Chicago has planned such a great boulevard on a most ambitious scale, the cost of which will involve many millions of dollars. Liverpool has in a less spectacular fashion but in a farsighted way gone about the creation of such a street which will permit traffic not destined for the central part of the town to pass entirely around it and avoid the most congested areas. Brussels has laid out and is gradually improving a similar great boulevard, the easterly portion of which, traversing the most highly improved part of the city, is one of the finest streets in Europe.

In every city there are large areas not yet developed and not even planned, where opportunities are presented to design a street system, the different parts of which will be properly located with respect to each other and to such modification of the system of the existing town as may ultimately be carried into effect. Too often these undeveloped sections are planned as if they were so many different urban areas unrelated to each other or to the original city, and too often the obvious blunders of the older sections are repeated in the new additions. While a city cannot often be planned from the beginning, there are certain general principles which should be regarded in the laying out of the street system of a portion of a town as well as of a complete city. These were outlined in a paper presented by Mr. Raymond Unwin at the London Town Planning Conference in 1910 in the following words: "Having settled the purpose of the different areas, determined the general character of the growth and the approximate direction desirable for main and subsidiary highways, the town planner finds himself with the following component parts out of which to make his design, namely: the main center point, or climax, dominating the whole; the secondary centers in definite proportion and relation to it; and the main highways linking them up; the whole giving the bones or main framework of the design. Within the space defined by this framework, having special relation to the secondary centers and proportion to the primary highways, we have the network of secondary highways; while within the areas which these leave, for the purpose almost solely of giving access to the buildings, we have the minor roadways or drives, which should be in relation to any subsidiary center

point, and both in relation and proportion to the framework of the secondary highways. * * * * In town planning it is essential to avoid being carried away by the mere pattern of lines on paper. Order, definiteness of design there must be, but there must first be grasped an understanding of the points where order is important and will tell, and of those where it matters little''.

In nearly all cases where a street plan is to be devised, whether it be for a large area which can be treated almost as an entire city in itself, or for a smaller tract contiguous to the built-up portion of an important city, the first essential is an accurate plan of the existing roads showing their widths and the buildings fronting upon them. These roads will be of two kinds,—old highways which serve to connect villages or centers of population, some within and others without the area to be platted, and roads or streets which may have been laid out as parts of real estate developments and according to which property may have been sold, but along the lines of which there has been little or no building. The former class of roads have a good excuse for their existence and they serve a useful purpose; they lead where people want to go and are likely to be fairly direct. Their alignment may be somewhat faulty, their grades may be excessive in some places, and their widths will be inadequate in view of the fact that they will naturally become the main lines of traffic for the urban district which will include them. With such straightening and widening as may be deemed necessary and such changes in line as will reduce excessive grades, these old roads will be the logical basis of the street plan which is to be prepared. When they have been platted, it will be obvious that additional roads will be needed, some to establish cross connections, others to give greater directness to the roads traversing the entire territory, others as by-passes around groups of buildings so located as to render the widening of some portions of the old roads unduly expensive, and still others to furnish lines of main drainage along the valleys through which the lateral sewers and subsidiary trunks must ultimately find their outlets. This system will be ''the bones or main framework of the design'' referred to by Mr. Unwin. (Fig. 7.)

While no one can predict with any certainty the precise manner in which any city will grow, the purpose of the preliminary design which has been outlined is to establish lines of least resistance which future development is quite likely to follow. The streets laid down in this plan will probably become the main arteries of traffic which will lead with reasonable directness where people will wish to go. They will divide the territory into a series of irregular figures having three, four or more sides, which sides may be a quarter or a half a mile or more in length. These areas must be subdivided by secondary roads in the location of which regard should be paid wherever possible to property subdivision, to the possibility of some of

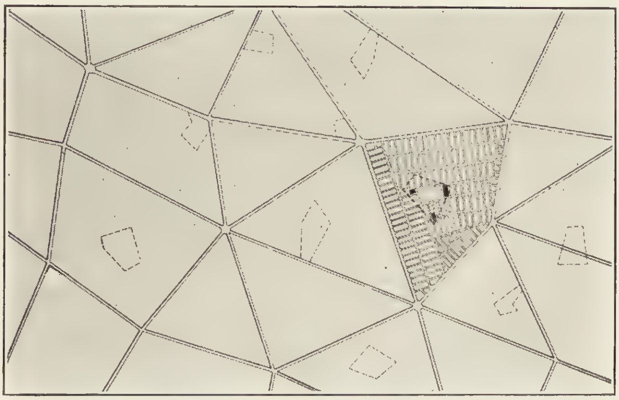

Fig. 7. Typical plan showing the development of an arterial street system, making use of existing roads with additional connections and the acquisition of acreage property for small parks, building sites, etc.

them developing into main traffic roads, and to the avoidance of awkward junctions with the main roads already laid down, which would result in confusion of traffic. It is difficult to say how wide the primary and secondary roads should be made. The Royal Commission on London Traffic in its report, made some years ago after an exhaustive study, suggested the following widths: main avenues 140 ft., first-class arterial streets 100 ft., second-class arterial streets 80 ft., third-class streets 60 ft., fourth-class 40 to 60 ft. This scale of widths may be somewhat over-generous and might involve unnecessarily great cost, but that such a commission should have proposed them shows that

its members were profoundly impressed with the handicap under which London has suffered by reason of its inadequate streets.

Lastly will come the minor streets which will serve almost entirely for access to dwellings. As all of these streets will connect directly with either the secondary or main highways, their alignment and grades are of little importance, as they will be used almost exclusively by private vehicles or those delivering supplies to the abutting houses. The chief concern is that they should be so laid out as to furnish ample light and air and discourage, if not prevent, a too intensive development with rear buildings in case the city ordinances do not prohibit this menace to health and decent living. To plan far in advance the precise location of these minor streets is not necessary, if it be not unwise. There is no reason why a street which is to be devoted to private residences should be long and straight. Among the most attractive features of a city are small residential areas treated in a distinctive way, each with a character of its own, which the visitor stumbles upon with agreeable surprise. If these minor subdivisions are planned at different times or by different persons, this variety in treatment is more likely to be realized. The important thing is that the diagonals or the main arteries be planned first, and that leading off from them will be highways of secondary importance, from which again will branch the smaller and less important streets. As the author has elsewhere stated, "A city does not, or should not, grow by accretions of fully developed areas; neither should its street plan expand by the addition of one completely platted area after another. Its growth is not like that of the human frame, beginning with a structure complete in every detail and gradually increasing in size. The skeleton should be created first. The position of the various parts of this skeleton will be controlled by the topography, and by the crude but suggestive system of roads which has already developed, each of them for a fairly good reason, namely, that it leads where people wish to go. Those who go to these now unimportant centers will doubtless wish to go in the same direction, and these roads will naturally become the important streets of this new part of the city. Additional connections will naturally suggest themselves,

and the entire street system will, if intelligently controlled, be developed in a rational manner along the lines of least resistance, and this part of the city at least will be adapted to convenient movement, orderly business and wholesome living''.*

Some special developments may have already been planned before the main and secondary street systems have been established, and these, provided they have been laid out with due regard for sanitary conditions, can usually be incorporated into the final plan. Many or most of the lots may have been sold to innocent purchasers, and to ignore them or to lay out a new system of streets without regard for them would impose upon the new owners a real hardship and an expense which might be serious, while the original developer is likely to have ''unloaded'' and to have put himself beyond the reach of punishment for his disregard of the public interest if there shall have been such disregard. (Fig. 8.)

While directness is desirable in the main and even the secondary streets, it does not follow that such streets should be perfectly straight; in fact, straight streets are seldom interesting. Neither need circumferential or curved streets be laid out with perfect symmetry. The great boulevards of Paris consist of a series of chords of varying length with deflections at different angles, yet their pleasing effect is in no wise diminished. Symmetry on a plan and symmetry on the ground are very different things. In studying a plan the slightest departure from such symmetry is noticeable, but on the ground it cannot be detected. One can ride or walk along a boulevard following a sweeping curve and be unconscious of the fact that its radius is frequently changing, while if examined on a plan these changes are at once apparent. Even if such a boulevard were broken into short straight sections, the utility of the street and even its beauty, so long as its general direction is preserved, are practically as great as if its lines were perfectly straight or symmetrical, and it undoubtedly acquires added interest from the fact that important buildings located at the points where the direction is changed will show to excellent advantage, and interesting street pictures may thus be formed. In the case of the minor streets there is still less reason for straightness or

* Third International Road Congress, London 1913, paper No. 5.

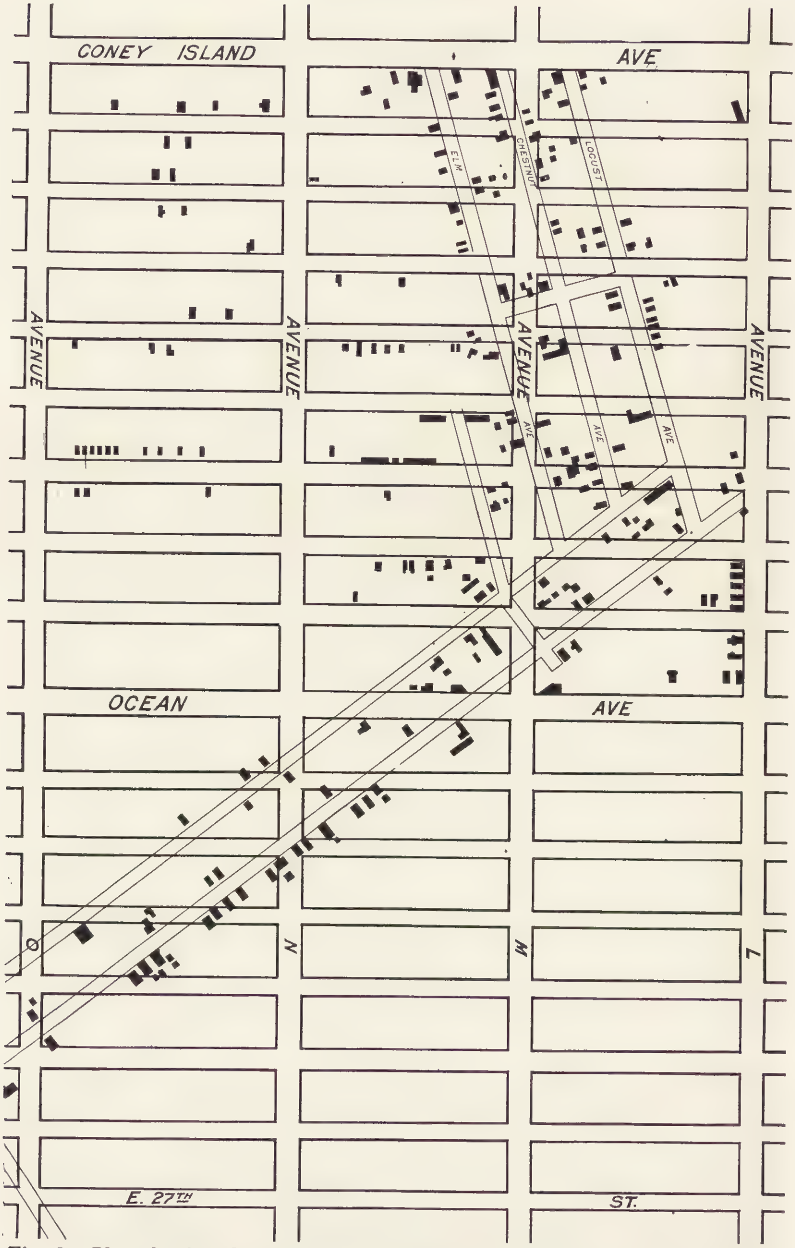

Fig. 8. Plan showing the disregard of existing improvements by carrying a rectangular street system across old streets which could, without serious objection, have been incorporated in the plan.

even directness. In German cities there is a marked tendency to introduce deflections and irregularities. An excellent illustration of this policy is afforded by the city of Essen where a deliberate attempt is made to limit the line of vision to from 650 to 1000 ft. (Fig. 9). Cul-de-sacs are found in many old towns of which they are often a picturesque feature, and some writers on city planning have protested against their abandon-

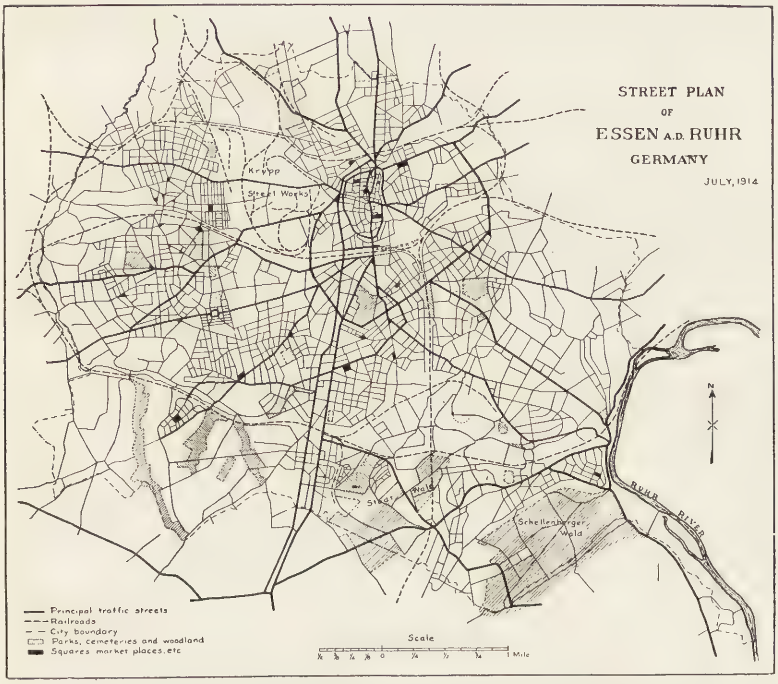

Fig. 9. General plan of the city of Essen, showing the studied irregularity of the street system, in which the street views are limited to from 650 to 1000 ft.

ment in modern city planning. When they terminate in a space sufficiently large for turning, they often furnish a quiet and attractive place for modest homes, but from the point of view of traffic, good sanitation and fire protection, they are objectionable. In the subdivision of an unusually large or awkwardly shaped block, the same effect can often be secured by laying out a court in the central portion of the block with two

or three outlets, avoiding thereby the objections which are inevitable in the case of cul-de-sacs. (Fig. 10.)

PARKS AND RECREATION FACILITIES.

While most cities have had as their nucleus some public open space where the people were accustomed to gather for

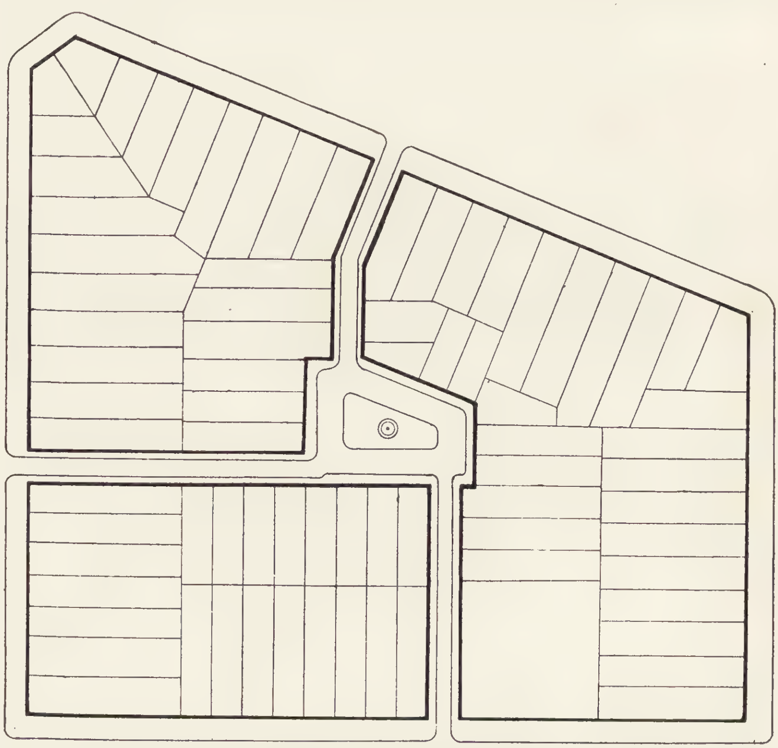

Fig. 10. Plan showing subdivision of an irregular block by the creation of an interior court with a small park and with three outlets.

meetings or for amusement, the creation of a system of parks or playgrounds has been quite a recent development in city building. In the capitals of Europe some of the parks were developed during the seventeenth and eighteenth centuries as royal pleasure grounds. They were laid out on a most extensive scale and were adorned with sculpture, fountains and other decorative features. It was in the design and construction of

these great royal estates or parks that the profession of landscape architecture, as we know it, came into existence. Such parks are now either the common property of the people or, if still nominally an appurtenance of the Crown, the public has the free use of them, and the chateau or schloss or palace about which they were laid out has become a picture gallery or historical museum. The city park, located, acquired and developed as a public playground, is a modern idea and is a result of the steadily increasing size of our cities. The park system, however, is usually of haphazard growth and its place as a part of the city plan is not yet fully appreciated, although its title to such recognition has already been pointed out. It is obvious that the needs of a city for open spaces cannot be anticipated to the same degree as can its requirements for transportation and a street system. Estimates have been made of the percentage of a city area which should be devoted to parks and of the proper number of people to each acre of park lands, but the needs of an urban community cannot be determined in this manner. The compactly built city where the individual dwellings have no open spaces about them, where the streets are narrow and where the average number of occupants to each dwelling is large, requires a greater park space per capita and a larger space in proportion to the area of the city. On the other hand, where dwellings are detached and each has its garden, where the streets are broad and lined with trees, the need of parks is much less. The industrial town or district has a far greater need of such reservations than does the residential town or district, while it usually has less. The great variation which is found in the park areas of different cities in proportion to population and total area of the city, is indicated by the accompanying table (p. 33) in which are given the average density of population of the area within the city limits and the area of park reservations within or contiguous to the city. It will be seen that Paris exceeds all of the other cities in the list in density of population, being compactly built within the old city walls and not having annexed adjacent territory, but its park area is greatest in proportion to the area of the city, owing to its two great contiguous parks, the Bois de Boulogne and the Bois de Vincennes, while it has one acre of park for every 554

of its population, although the open spaces in the built-up portions are very meager. Berlin comes next in density of population but greatly exceeds all other German cities in this respect, while its park area, though slightly above the average in percentage of the area of the city, is less in proportion to population than those of the other cities except Marseilles and Lyons. In marked contrast with the cities mentioned is the national capital of the United States which has but nine people to the acre, has devoted 14% of its area to parks, which include the spacious grounds around the public buildings, and has an acre of open space to every 68 of its population. Kansas City, while having a density of population of but eight to an acre, has devoted 5% of its area to parks and has an acre of park land to every 144 of its population. A feature of the Kansas City parks is the very complete system of parkways or boulevards by which they are connected and which has a combined length of more than thirty-five miles. (Fig. 11.) The wide variation in the proportion of park area to total area and to population will show the futility of attempting to estimate the actual park needs of a State in percentages. Mr. Charles Downing Lay, editor of "Landscape Architecture", formerly landscape architect of the New York Department of Parks, in a paper read before the Conference of Mayors of the State of New York in 1914, estimated the park needs of a community of 100,000 people as follows:

Wild parks	700	acres
One large rural park	400	"
Ten small parks	250	"
Fifty playgrounds	100	"
Gardens, squares, etc.	50	"
Total	1,500	acres

He assumed that 12½% of the area of the city would be devoted to parks, or that the city would cover 12,000 acres, giving an average density of population of 8-1/3 persons per acre and an allowance of one acre of park to 66-2/3 people. This generous allowance is closely approached by Washington, which even exceeds the percentage of area devoted to parks. Boston approximates Mr. Lay's suggestion as to the proportion of its area to be given over to parks and, if her great wild parks

which are not contiguous to the city are included, has greatly exceeded it, and Dusseldorf is not far behind, but these two cities are so clearly exceptional as to be in a class by themselves. It is frequently argued that it is folly to select and acquire park reservations until the actual need of them is imperative; that they can then be placed where that need is greatest, that the

Table Showing Park Statistics of Various Cities.

City	Population	Area in acres	Parks		Population	
			Area acres	% of total area	Per acre of city	Per acre of park
London (Met. Dist.)	7,251,358 *	443,424	15,901 [1]	4	16	456
London (Adm. County)	4,521,685 *	74,816	6,675	9	60	677
New York	5,333,539 §	189,662	7,738	4	28	689
Paris	2,847,229 *	19,279	5,014	26	148	554
Chicago	2,393,325 §	124,448	4,388	4	19	545
Berlin	2,082,111 ‡	15,696	1,034	7	133	2,014
Philadelphia	1,657,810 §	82,933	5,143	6	20	322
Hamburg	1,006,748 †	30,527	808	3	33	1,246
Birmingham	840,202 *	43,601	1,414	3	19	598
Liverpool	760,000 §	21,219	1,282	6	36	593
St. Louis	734,667 §	39,100	2,765	7	19	266
Boston	733,802 †	27,612	3,545 [2]	13	27	207
Munich	636,000 ‡	23,633	1,783	8	27	356
Leipzig	615,000 ‡	19,217	570	3	32	1,079
Baltimore	579,590 §	19,290	2,402	12	30	241
Cologne	544,400 ‡	29,001	745	3	19	731
Marseilles	528,000 *	6,176	210	3	87	2,562
Lyons	523,796 *	10,045	257	3	52	2,038
Sheffield	476,971 §	24,347	682	3	20	699
Dusseldorf	407,000 ‡	27,562	2,738	10	15	149
Washington	353,378 §	38,400	5,212	14	9	68
Kansas City	281,911 §	37,443	1,952 [3]	5	8	144
Rochester	241,518 §	17,352	1,836	11	14	133
Averages including the County of London, but not the Metropolitan District				6.32	30.5	483

*, †, ‡ and § represent population in 1911, 1912, 1913 and 1914, respectively.

[1] Of the park reservations in the London Metropolitan District, 4,026 acres are owned and maintained by the Government, 5,070 acres by the London County Council, 6,491 acres by the City Corporation, and 314 acres by the several Metropolitan Borough Councils.

[2] This area does not include the system of wild parks outside of the City of Boston but within a radius of fifteen miles. These parks have a combined area of 9,405 acres and if they were included, they would make the total park area 47% of that of the city and would reduce the number of people per acre of park to 57.

[3] Kansas City, in addition to its park area, has an unusually complete system of connecting boulevards and parkways with an aggregate length of more than thirty-five miles.

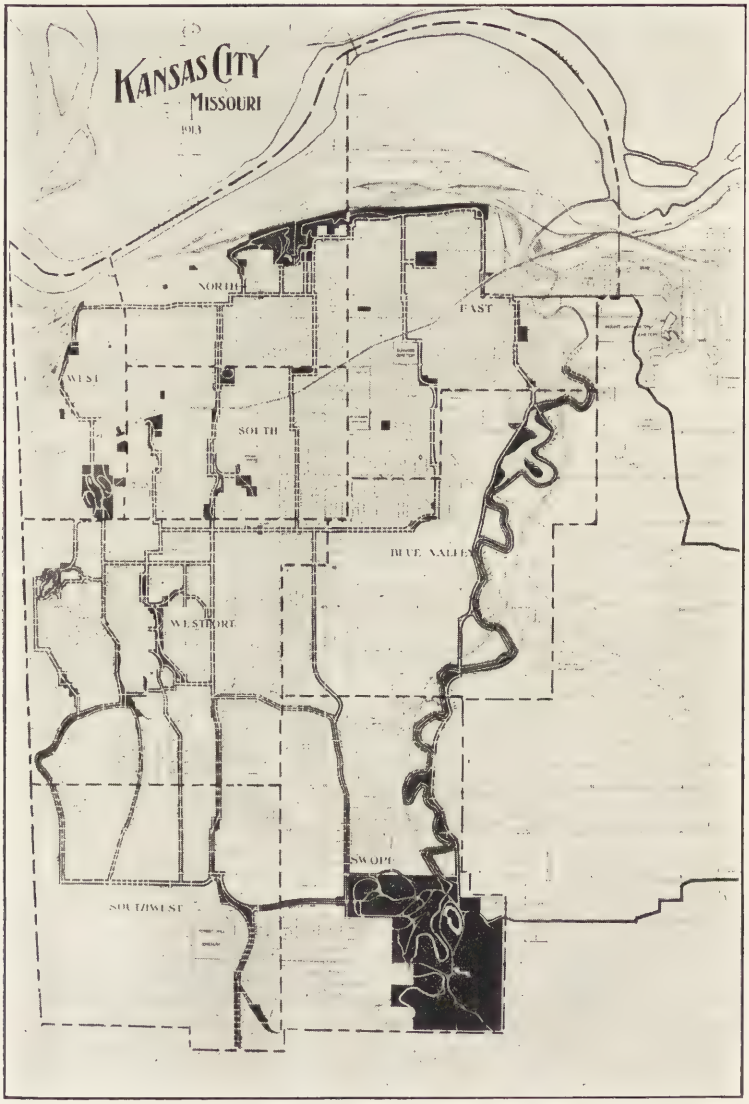

Fig. 11. Plan showing the complete system of parks and parkways of Kansas City and the several park districts upon each of which is assessed the cost of the parkways within its boundaries.

additional expense of their acquisition at the enhanced value, and on account of the destruction of buildings, will be less than the carrying charges and loss of taxes, and that, unimproved parks being of little value, their development at great cost is likely to be undertaken prematurely if purchased before they are actually needed. There may be some instances where this has proved to be the case but they are exceptions rather than the rule. The unrelated and inconveniently located parks in many cities indicate quite clearly that the course above referred to has been followed and that when they were acquired, the most available and cheapest land which offered itself was taken, with little regard for the location of the different park units with respect to each other.

The argument that a park should not be acquired unless it is to be improved at once is an unsound one. Public pleasure grounds may be divided into three classes,—the wild park where the natural conditions remain undisturbed as far as possible, the developed park where by skillful treatment and planting such natural features as meadows, woods and lakes are combined, and the formal park which is more in the nature of a garden. A city park if of sufficient size may pass successively through these stages. There is no greater boon to the city dweller than the opportunity to frequent a place where nature has been interfered with to the least possible degree. A few walks or roads through the woods are all that is necessary in the way of improvement. As such parks become more frequented and as their natural beauties are more likely to be destroyed, a greater degree of development with more strict policing may be required and gradually the wild park becomes a developed park while portions of it may in time be treated as a formal garden. This process of evolution may cover a decade or a generation and meanwhile other wild parks lying further out may be acquired.

The land which will in time make the best parks will often have been passed over by the real estate developer as unsuited to his purpose,—precipitous hillsides where the cost of development would be prohibitive, creek bottoms or meadows which may be subject to periodical flooding, wooded tracts somewhat off the lines of transit, even marshes which are unfit for devel-

opment until thoroughly drained,—any or all of these present great opportunities for effective and economical development into parks. Their actual value is small, the return from them in taxes is insignificant, and to carry them until their development is needed will not be a serious burden. The planning of a park system should receive as careful study as should the planning of a transportation or street system, and it is just as much a part of a comprehensive city plan. While it is obviously impossible to formulate as definite a plan for parks as for streets, there must be some relation between them, not necessarily an economic relation, not even a ratio between the total area of parks and that of the city, not a maximum and minimum of size nor any standard as to their shape. It may be said that in planning a city the park reservations should be governed by the street system. While this is true, the streets should also bear some relation to the park system. It is not an uncommon practice to lay out a street system for the entire territory to be platted with the idea that when the time comes to decide upon the extent and location of the parks, such streets as interfere with them can be discontinued, and that at least one entire block here and there will be taken for parks and in some cases a group of blocks. Streets which connect the different park units are commonly given the dignified name of parkways. This designation is often misleading. A street so named should have some of the characteristics of a park. It should at least be well planted with trees and have a roadway devoted to restricted traffic. Because a street or avenue leads from one park to another or because jurisdiction over it is vested in a park department or commission, it is not necessarily a parkway. In planning a system of parks provision should be made for connecting them. Experience seems to show that streets more than 100 ft. in width rarely develop into business thoroughfares. Consequently, if those which are to serve as park connections or parkways are given a width of from 120 to 150 ft., business will be likely to avoid them, while such width will be sufficient to provide certain park features when the time comes for their development.

The judicious selection of the park areas will require skill and judgment, and the advice of a competent landscape

engineer or architect should be secured. To defer this until the time comes for actual development is unwise. Expert knowledge as to the possibilities of the different park sites is worth far more than skill in adapting an unsuitable site to the desired purpose. The precise size and boundaries of a park need not be determined when the land for it is secured. It should be bought as acreage property and its boundaries may be irregular. When the street system about it is finally fixed, the park can be trimmed down to such form as is desired and to such size as the locality will probably require. Some of the land which has been taken may be left outside of the boundaries finally decided upon. It may be a few building lots or it may be several city blocks. In the latter case an admirable site for a school or library will be provided which will front upon the park, while perhaps a block away there may be convenient and not too conspicuous sites for a police station and a fire engine house. In either case there may be land left which can be sold at such an advance over its original cost and carrying charges as will materially help to pay the cost of the park. (See Fig. 7.)

Every city of considerable size has one or more large parks, sometimes in the very heart of the city if it was acquired at an early date, often on the city's outer edge. While these parks are invaluable, many people cannot afford even the small fare to reach them, and it is the smaller neighborhood park that really counts for most in the every-day life of the masses of the people. These small parks should be so located that one of them is within easy walking distance of every part of the city. Mr. John A. Brodie, the City Engineer of Liverpool, has suggested that in planning a system of parks they should be carried out radially from the center of the city somewhat in advance of its development, and that in large cities wide streets can be combined with open spaces which will practically become part of the park system of the town. Dr. Werner Hegeman points out that such a radial system of parks and boulevards will provide "a broadcast fresh air drainage for the whole city".

THE LOCATION OF PUBLIC BUILDINGS.

The designation "public buildings" is commonly used in a very restricted sense, and as applying only to those in which

the business of the nation, state or city, may be conducted. In their relation to city planning, there are many others which can properly be called ''public buildings'', not only such as libraries and museums which are much frequented by the public, but all of the buildings constructed and maintained for the exercise of any of the functions performed by public authority, such as schools, penal and charitable institutions, markets, hospitals, police and fire houses, baths, and structures connected with water supply and drainage. They may also include churches and buildings used for amusement and entertainment under private as well as public management, and the various buildings and plants, many of which in European countries are maintained by the public authorities, but which in America are commonly left to public service or other corporations, among these last being railway stations and terminals, lighting and heating plants, financial institutions, etc. In ancient cities individual dwellings were modest and unpretentious, while public buildings were dignified and beautiful. The cities were rich and powerful, and their buildings were planned and adorned for the purpose of impressing their citizens and those of other cities with their power and dignity. Churches and cathedrals were the expression of the devotional spirit of the people, and their wealth and their labor were lavished upon these structures, whether enthusiasm, superstition or fear of ecclesiastical tyranny may have prompted their giving. The powerful guilds erected beautiful buildings which were commonly grouped about ''places'' which were dominated by the Rathaus or the Hotel de Ville or a church in such a manner as to produce charming and dignified effects. There has lately been an awakening to the importance of the better design and grouping of such buildings, and a number of plans have been made, especially in the United States, for the creation of civic centers, many of which attain a degree of imposing dignity and even grandeur which at least equals anything heretofore accomplished. The greatest impetus in this direction was probably the object lesson given by the wonderfully effective arrangement of the principal buildings of the Chicago Exposition in 1893 which, as already noted, gave great stimulus to the modern city planning movement, if indeed it did not start the movement, at least in America.

Some fine public buildings, admirably located, were to be found in the United States before this new interest developed, notable instances of which are the National Capitol at Washington and the City Hall in New York. The latter was erected during the first decade of the 19th century in a triangular park which has lately become an oasis in a district fast being given over to skyscrapers. The municipal authorities foolishly permitted the United States Post Office to be erected at the apex of this triangle, and then built a large Court House directly in the rear of the City Hall. Both of these buildings are of poor design and, while the City Hall itself has been jealously preserved, its setting has been spoiled. Efforts are now being made to secure the removal of the Post Office building, while a new Court House is about to be built on a different site, and it seems likely that this little park will be restored to its original purpose, a fitting site for one of the best City Halls, from the architectural point of view, in the United States. Many of the state capitals have been given spacious and commanding sites, of which those of St. Paul and Hartford may be noted as excellent examples. The cities of Continental Europe give far more consideration to the location and design of their public buildings than do those of Great Britain and the United States. The Continental buildings may be inconvenient and somewhat shabby and almost entirely lacking in the facilities for expediting public business which are found in the United States, but every detail connected with the past history of the city has been carefully preserved. Frankfort has grown very rapidly during recent years but it did not occur to the city authorities that they might tear down their old "Romer" and build a large modern City Hall, as Leipzig has done. Instead of this, other units of a design harmonizing with the ancient building have been added from time to time to meet the need of more space, and the result is admirable. Such buildings have been better designed in recent years and more consideration has been given to the selection of their sites, but the gridiron plan of most cities in the Western world does not permit them to be seen to advantage. The huge City Hall of Philadelphia, 486 by 470 ft. in size, with an inner court over 200 ft. square, was erected at a cost of more than $18,000,000. The centers of each of the four sides are pierced by arches 18 ft. wide and 36 ft. high, affording access

for pedestrians to and across the central court on the lines of the two intersecting streets which lead directly to it, one of these streets being 113 ft. and the other 100 ft. in width. While portions of the façades can be seen from great distances on one of these streets, the remainder of the structure is surrounded by large buildings grouped closely about it, one of which is the Pennsylvania Railroad Station. A great parkway is now being constructed which will approach the City Hall obliquely, its axis passing directly through the Penn Statue which surmounts the great tower of the building, rising to a height of 584 ft. above the street level. The new Public Library building of New York, erected at a cost of about $10,000,000, occupies one end of a small park, with a frontage of 460 ft. on Fifth avenue, but its beautiful lines can nowhere be seen to advantage.

In Continental Europe, especially in Germany, the important railway stations are treated as gateways to the cities and front upon generous open spaces, while the railway terminals of London, New York, Chicago and St. Louis, and other British and American cities, are hedged about by solid blocks of buildings so that no satisfying view of them can be obtained. The beautiful Pennsylvania Railroad Station in New York, occupying two city blocks and what was formerly an intervening street, with an area of more than 8-1/3 acres, cannot be appreciated. The new Grand Central Terminal of the New York Central Lines is more fortunately located in that it is centrally placed with respect to the axis of Park avenue, 140 ft. wide, so that the building can be seen when approaching it by this avenue, either from the north or south. (Figs. 12 and 13.) The substitution of electricity for steam as motive power at railway terminals may have far reaching results. When operated by steam, the New York Central Terminal was a noisy, unsightly intrusion into one of the busiest and most attractive parts of the city. When the improvement of this terminal was undertaken and the substitution of electricity for steam was determined upon in 1903, the possibility of using the space above an electrically operated terminal was not realized. One large and important building has now been erected over the tracks and it is apparent that all of this enormously valuable space over what was formerly a railway yard in the very heart of a great city will be

available for profitable use, and that the revenue derived from it will go far towards meeting the interest on the immense cost of the undertaking. With an appreciation of the importance of a dignified treatment in the vicinity of this terminal, the company has declared its intention of restricting the height of the

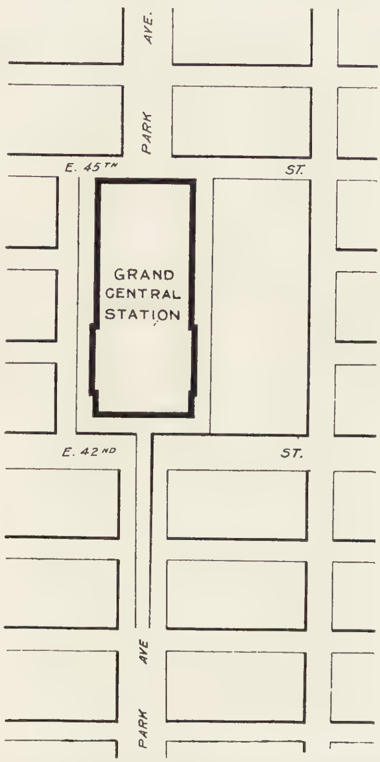

Fig. 12. Plan showing the location of the Grand Central Station, New York City, with an avenue 140 ft. in width approaching it from the north and south.

buildings over its tracks and along Park avenue north of the station to an elevation corresponding with the cornice line of the station building itself, so that this portion of the avenue is destined to become one of the most dignified streets to be found in this or any other city. The Union Railway Station in Washington is not only a very beautiful building but it fronts upon an open space larger than any other "station place" known to

the author, and in close proximity to the Capitol building. The location of the great railway station of St. Louis, surrounded by narrow streets, suffers greatly by comparison, as do the railway stations of Chicago, including even the latest and most modern, that of the Chicago and Northwestern Railway. London's great railway terminals are inadequately provided with ap-

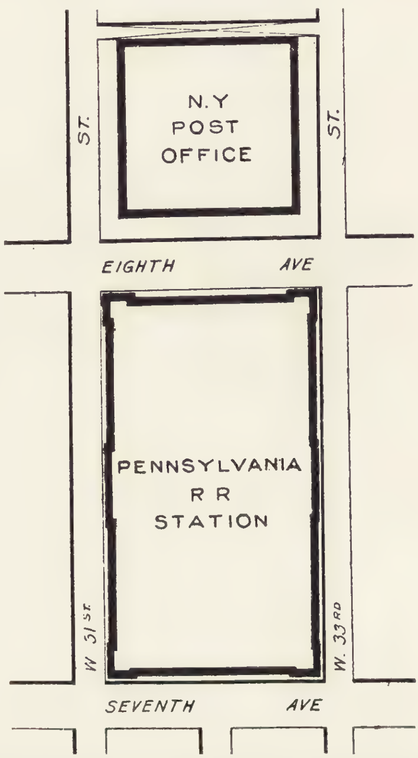

Fig. 13. Plan showing the location of the Pennsylvania Railway Station and the new Post Office in New York City, showing the narrow streets through which the only views of the structures can be obtained.

proaches and have no open spaces worthy of the name in front of them. The Liverpool Street Station, through which it is said that more people pass daily than through any other railway terminal, is particularly ill provided with spaces about or approaches to it. In Edinburgh, on the other hand, the two great stations, the North British and the Caledonian, are located one at each end of the beautiful gardens along Princes street. The

British and some of the Continental stations have their ugliness screened by the railway hotels owned and operated by the companies, although behind them are to be found the inevitable train sheds with their smoke and noise.

Public buildings have generally been moderate in height and have conformed quite closely with old established architectural traditions. New York City, however, has lately erected a municipal office building twenty-five stories in height with a tower containing some fifteen additional stories, after designs made by McKim, Mead & White. It covers what were formerly two irregular blocks and the intervening street, which is carried through it, and fronts upon the City Hall Park for the greater portion of its length so that it does not shut off light or air from other buildings. This building accommodates some 6,000 city employees and has a total combined area on all the floors of 1,250,000 sq. ft., with usable office space including corridors of 725,000 sq. ft. If 15% be added to this for utility space, a five story building offering the same accommodations would cover 166,750 sq. ft., exclusive of light and air courts. These would probably amount to one third of the building area so that the site required to accommodate a five story building with equal office space would be over 470 ft. square, or if on a block 200 ft. wide the site would have a length of about 1,110 ft. Owing to the peculiar shape of its site, this building has no courts, and every office is a front room with ample outside light. As it is located over an underground railway station, the heating plant is placed beneath an open space at one corner, while the fourth floor above the street level is given up to the accommodation of the complicated system of pipes, conduits and hydraulic and electrical devices incidental to a modern office building and usually placed in the basement or subbasement. (Fig. 14.)

Another instance in which New York is violating an established precedent is in a new Court House which is about to be erected in accordance with plans made by Mr. Guy Lowell. This building is to be circular in shape with a diameter of 386 ft. and a height of 204 ft. above the street, with eight stories on the front and thirteen stories on the central court. A site was chosen and acquired which located the center of the building

Fig. 14. The new Municipal Office Building of New York City, built over a street 60 feet in width.

on the axis of an important street and over a four track underground rapid transit railroad. Owing to the character of the soil underlying this site and on account of the difficulty of spanning the underground railroad, it is proposed to change the location somewhat, and additional land has been acquired for this purpose. The Court House site, which is large enough to accommodate some other public buildings and also provide a bounding street, will be in close proximity to the City Hall Park and the Municipal Office Building, thus forming a somewhat irregular civic center.

The effective grouping of public buildings to create civic centers has received much attention of late and appears to have become somewhat of a passion in American cities. Numberless towns, great and small, and even villages, are now studying this problem. Many of the plans will never be realized, but one of the first to be undertaken, that at Cleveland, is now being carried out. It was particularly fortunate in this case that the principal railway station, located on the lake front, could be made a part of the plan which comprises a rectangle 500 ft. in width and extending back 1900 ft. from the railway station which, located on low ground along the lake shore, will face the northerly end of this open space, with the City Hall and Court House, one on either side and set back somewhat from the side lines, directly behind it; while at the southerly end, opposite the railway station, will be the post office and library buildings.

The city of San Francisco is carrying out and has already completed the most important part of an effective scheme for the grouping of public buildings. The conspicuous feature of this plan is its adaptation to the previously existing street system. The former triangular site of the City Hall is devoted partly to sites for new buildings and partly to a broad approach. Four city blocks are given up to a plaza about which the buildings are grouped, while the site of the new City Hall covers four additional blocks.

The aim of city planners and architects is usually to locate public buildings, whether isolated or in groups, so that each building shall be a single unit, even though it may bear a certain relation to others. Each building is given a site of its own with due regard for those of its neighbors. There are those who

strongly urge the avoidance of an appearance of isolation, even in buildings of the greatest importance, maintaining that great buildings are seen to far better advantage when flanked by those of minor importance or when even physically connected with them. The artistic judgment of these writers or critics will not be questioned, but this paper is frankly written from the view point of the engineer, of the men who will largely control the general plan of the city, making it easy or difficult to select sites for public and semi-public buildings and without the costly and disheartening necessity of tearing down buildings, and rearranging streets in order to provide proper sites. If there are smaller structures on adjacent plots which will enhance the beauty of the more important buildings, they can remain; if necessary, they can be built. If competent authorities decide that they should go, they can readily be removed. The small and shabby shops which cluster about the Antwerp Cathedral are held by some to enhance its beauty; by others, to detract from it. The cathedral of St. Bovan, the church of St. Nicholas, and the old Belfrey in Ghent, each standing by itself, are said to suffer from their isolation and perhaps this criticism is just. But no city plan likely to be made today would contemplate such locations. It is difficult to imagine anything more pleasing in its simple dignity than the New England village green with the church or churches and the Town Hall placed either in it or fronting it. They are not connected with other buildings in order to secure a picturesque effect; each has its own site. They are in many respects isolated, yet the impression they create is a very satisfactory one.

ADAPTATION TO TOPOGRAPHY.

That the various elements of a city plan as heretofore outlined should be adapted to the topography of the site seems so obvious as to need no special emphasis, yet there are numerous instances where this has been done only to a limited extent. The topography should, in fact, be the first thing to be considered in determining the general features of the comprehensive plan. Upon it will especially depend the system of main drainage, provision for which must be kept in mind from the beginning, and the transportation system which, while it will natu-

rally be designed to carry people where they want to go, should be able to follow the lines of least resistance, excessive grades and sharp curves involving not only heavy operating expenses but a certain amount of danger. A street plan prepared in the office without sufficient information as to the topography of the ground upon which it is to be laid out may look very well on paper but is likely to be found entirely unsuited to actual conditions, and if persisted in may impose a heavy initial burden for the construction of the streets and a perpetual handicap upon traffic by reason of unnecessarily heavy grades. The first step, therefore, is to secure a good topographic survey of the territory to be platted. Sometimes this initial survey is made in far more detail than is necessary, the idea being that a complete street plan is to be made at once. The folly of doing this has already been emphasized; the time and expense of doing so could be used to better advantage in a study of the larger aspects of the problem or in working out only the skeleton plan. Topographic surveys are expensive and the work of planning the street system should not be loaded up with needless cost at the start. The survey required for the first study should show existing roads with the location of buildings fronting on them, the actual drainage, including both the valleys and the ridges dividing the drainage areas, the existing railroads and routes suitable for additional lines, the waterfront, if there be one, and the localities best adapted to the accommodation of water borne commerce and the places which, from their picturesque features, are most suitable for park reservations. Further details are not required for the first study of the plan; they will come later. A contour map or a model will be of great help in laying out the first skeleton plan. When this has been determined and the time comes to fill in the details, further surveys will be necessary, but they can be taken up one section at a time as each of the areas lying between the arterial streets can and should be studied separately. In this connection, proper drainage should be the first consideration, while the location of property lines will be of great assistance in so planning the minor streets as to avoid damages, caused by leaving unusable remnants, wherever it is possible to do so, and still secure a rational and convenient plan.

The first step in the physical creation of a street system is the grading, and as this comes at a time when the value of the abutting property is small, the cost should be kept down to the lowest figure consistent with a reasonable plan. The preference for rectangular blocks which will produce the greatest possible number of right-angled lots is so general that excessive grading and needlessly steep grades are frequently the price paid to secure them. This policy often defeats its own purpose, as the grading up or down of the abutting lots is likely to involve a cost greater than the value of the few lots gained by a rectangular system over those which would result from one conforming more closely with the natural surface, while the latter would be far more attractive. There is something of a reaction against the rigid rectangular plan evidenced by the introduction of curves and deflections, even where there is no obvious reason for them. A long sweeping curve may be a pleasing feature of a street plan on level ground; diagonal streets to afford direct access from one part of the tract to another are always desirable; but a series of sharp curves and frequent abrupt changes of direction are as inappropriate for a level site as are straight lines regardless of natural contours for a rugged site.

The sites for public and semi-public buildings should receive consideration in the first topographic survey. Such buildings should not only be placed where they can be seen from the streets approaching them, but, wherever possible, they should be placed at grade summits. Excellent examples of the proper and improper location of monumental structures are given by Mr. H. Inigo Triggs in his book on Town Planning. The Arc de Triomphe of Paris is placed at a grade summit where it can be seen from all directions, while the Chateau at Versailles is placed so far back of the crest of the hill on which it is located that only a portion of its roof can be seen by one approaching it from the west, although broad avenues radiating from the Place d'Armes at its eastern façade afford pleasing views of the building.

There may be some precipitous hillsides or deep ravines in the area to be platted and, while these are of little value for other purposes, they will make admirable parks. They should be located in the topographic survey and the main roads should

be so fixed as to afford easy access to them when they become public pleasure grounds. The general plan should be adapted to the topography. Attempts to create on a level plain a city having the picturesque features of a hillside town will result in failure, while to lay out on a rugged site a plan suited to a level or gently sloping tract will not only involve needless expense, but will sacrifice opportunities for charming effects and produce a result which is palpably commonplace.

STREET DETAILS.

While the general plan for the streets and roads of a city and its environs may have been well thought out, while the streets may be of generous width and of good alignment, and may have been skillfully located with respect to the topography, their traffic capacity may be less than it might be, owing to improper proportion of roadways and sidewalks. The roadway pavements may be unsuited to the character of the traffic or to the grades. Injudicious tree planting or the entire absence of planting may make them bare and unattractive. Lamp-posts and street signs may be conspicuously ugly, and inadequate lighting at night may render the streets gloomy, if not dangerous. There are many details of street arrangement and design which are worthy of the most careful study, and even when these details have been carefully worked out for one street, or even for streets of different classes and widths, a standard cannot safely be adopted for every street of the same class and width. The general subject of street construction is to be covered by other papers, but, while not desiring to encroach upon the field to be covered by them, the author feels justified in emphasizing the necessity of keeping in mind from the beginning the manner in which every street may be improved in order to give the most satisfactory results. The undesirability of long straight streets at fixed intervals, each of the same width, has already been pointed out. Equally objectionable is the identical arrangement of the minor details on each of these streets. There has lately been a reaction against this monotony of treatment with a tendency in some places to go to the other extreme. The avoidance of identical treatment of different streets has not seemed sufficient to some designers, and an unsymmetrical ar-

rangement of the same street has been urged and adopted by some distinguished authorities;—not only a variation in the treatment of different parts of the same street, which is usually pleasing, but a different treatment of the two sides of the same street, a single roadway being placed near one side and bordered by a narrow footway while wide walks, grass plots, shrubbery and trees are placed on the other side. (Fig. 15.) There are

Fig. 15. Typical example of the unsymmetrical treatment of streets in Essen.

special cases, such as hillside streets or where the property on one side is devoted to business and on the other side to residences, where the reason for such treatment is obvious, but when the improvement and use of the two sides of the street are similar and where no topographical conditions suggest an unsymmetrical treatment, it is difficult to understand why it is resorted to. It may happen that trees have been set out and have grown to good size before the street has been built upon,

or the houses on one side may have been set back from the street line and a widening of such a street becomes desirable. By resorting to an unbalanced or unsymmetrical treatment, such a widening of the roadway or two roadways of different widths can be provided without the destruction of the trees. In such cases an irregular or unconventional arrangement is clearly advisable even though the reason for it may not be apparent after the completion of the improvement. But where a single line of young trees occupies one side of a roadway and the sidewalks on the two sides of the street are of different widths and treated in a different manner, it appears as if the designer of the street were guided by a passion for irregularity as strong as has been the passion for sameness on the part of those who have made plans for most American cities. The importance of trees in a city street cannot be over-estimated. Mr. Charles Mulford Robinson says, "In the mental picture of a beautiful city or village, the tree has an inseparable part". Mr. Charles Downing Lay has observed that "tree planting cannot safely be left to individual enterprise, for a tree out of place is just as objectionable as any other misplaced object". The position of the trees should, therefore, be one of the street details to receive careful study. The practice of placing them immediately back of the curb is quite general, and where buildings are placed upon the street line it may be necessary to do so in order to give them space for growth, but this location is quite generally adopted even where there are set-back restrictions as to the abutting buildings. In such cases, if the trees are placed between the sidewalk and the building line, the street acquires an added dignity and appears to be wider than where the trees are placed along the curb.

The orderly arrangement of the great variety of structures beneath the surface of city streets is a subject which should receive careful consideration in city planning, but the lack of attention to this detail has been conspicuous. The provision of subways or galleries for the accommodation of all underground structures has frequently been urged as the only effective remedy for the conditions which so commonly exist and which involve the continual mutilation of the street surface in order to reach the various pipes, mains and conduits. A

brief reference to the experience of the various cities which have built subways for these pipes may not be out of place. London built its first pipe subway in Garrick Street which was opened to traffic in March, 1861. When the creation of this new thoroughfare was determined upon, it was decided that some means should be taken for "obviating the expense and inconvenience attending the breaking up of the pavement for the repair of pipes, mains, sewers, and other underground works". The plan was carried out and a subway 12 ft. wide and 7½ ft. high was built under the street. Since that time a number of such subways have been constructed, but only in connection with the creation of new streets, and during the half century and more since the improvement of Garrick Street the total length of pipe subways built in London has been only about 44,000 ft. Nottingham, the first city to follow the example of London, has built altogether about one-half a mile of pipe subways, and the City Engineer in referring to one of them in a paper read before the Incorporated Association of Municipal and County Engineers in April, 1892, said that "Not one single stone was disturbed in this carriage way for twenty-five years, and in that period not one single penny was spent in repairs on this street". This is certainly an impressive statement and would indicate that the provision of such subways may effectually prevent the mutilation of street pavements. At St. Helens, a manufacturing town of about 100,000 population, near Liverpool, there is a pipe subway a little over 2,000 ft. long, and in Glasgow, a short one 345 ft. long; and these, so far as the author knows, are the only pipe subways in any of the cities of Great Britain. Milan is the only Continental city which appears to have built a subway for pipes and mains, and this is a very small one only 6 ft. in height and 4 or 5 ft. wide. The sewers of Paris have been used to a limited extent for the accommodation of underground structures of the kind referred to, and it was originally the practice to place gas mains in them, but such pipes together with electric light and power conductors are now placed under the sidewalks. The municipal authorities believe it dangerous to allow gas pipes in the sewers and the structures in them are now limited to telephone and telegraph wires, water pipes, pneumatic tubes and hydraulic power pipes. Un-

derground pipes and conduits are not as numerous or as large in European cities as in those of the United States. In three of the more important subways in London, the average cross-sectional area of the pipes and conduits which they accommodate is 6.17 sq. ft., while in two sections of Broadway, New York, their average sectional area was found to be 44.05 sq. ft., or more than seven times as great as in London.

While the great number of these underground structures may be one of the contributing causes of the constant disturbance of street pavements in American cities, and the condition of disrepair which is so frequently found, it is not the only reason. It will be difficult to find two cities where the street pavements are in better general condition than Liverpool and Berlin, the former conspicuous for its excellent stone-block, and the latter for its good asphalt pavements; yet neither of these cities has built pipe subways, and the reason for the admirable condition of their streets is probably due to efficient administration and also to definite regulations covering the precise location of pipes and other structures of different classes beneath the roadways and sidewalks, avoiding thereby the exploration beneath the surface for the purpose of finding what is wanted, when repairs are necessary.*

HEIGHT AND OTHER LIMITATIONS.

Limitations as to the height of buildings, the proportion of the lot which may be built upon, and the general arrangement of buildings, are commonly referred to in the United States as restrictions. In European countries this term might not be clearly understood, as there it is quite generally taken for granted that the city will make such regulations as are calculated to insure to the citizens at large the full enjoyment of all the advantages which a well-organized city should supply, and prevent such acts of the individual or such use of private property as will in any way militate against such enjoyment. Among these advantages, besides the free and safe use of the public streets, the right to which is universally admitted, there may be included freedom of obstruction of light and air by a neighboring owner; prevention of the appropriation of public prop-

* See Report of Chief Engineer of the Board of Estimate and Apportionment of New York City on Pipe Subways in European Cities, 1910.

erty to private use; the guarantee of the preservation of the character of a district when once established by protecting it against invasion by industries, uses and occupations inconsistent with that character; the conservation of the value of private property by a consistent scheme of development and improvement; the prohibition of the erection of structures, either permanent or temporary, which will offend the eye, or of anything destructive of what the English so well and so frequently express by the word ''amenity''.

In many cities there is a disposition on the part of the abutting owners to make use of portions of the public streets for private purposes. The exposure of goods for sale on sidewalks in front of shops, the loading or unloading of bulky packages and barrels by means of skids extending across the sidewalks with complete interruption of their intended use, the erection of permanent platforms on parts of the sidewalks in front of shops and warehouses handling heavy materials, the erection of storm doors, porches, steps to floors above and below the street level, and even the storage of trucks and machinery in the streets at night, are not uncommon sights in many cities. In New York the practice of encroaching upon the streets by steps, porches, show windows, and even by supporting columns forming an integral part of the buildings, had become so common that the abutting owners came to consider them entirely lawful and efforts to remove them were resisted as an invasion of their fully established rights, even though this city owns its streets in fee for their full width. It was not until 1910 that the first systematic effort was made to correct this abuse. The first street selected for the enforcement of the right of the public to the free use of the entire width of the street was Fifth avenue, which had been laid out and acquired at a width of 100 ft. The roadway was 40 ft. in width with sidewalks 30 ft. wide on each side, but half of the sidewalk space had for many years been converted to private use and many costly buildings had been erected whose entrances, steps, supporting columns and pilasters extended beyond the street lines. Fences had been erected enclosing one-half the sidewalk and in some cases sunken gardens and ornamental planting occupied the spaces inside of these fences. When Fifth avenue became a business

street and the traffic greatly increased, the roadway of 40 ft. was inadequate, and it was decided that it should be increased to 55 ft. and that all the building encroachments should be removed. The entire expense of the changes was to be borne by the abutting owners and, in view of the claims which had long been made as to the rights of these owners through long established custom to use the streets for the ordinary appurtenances of a building other than the parts used for residence or gainful occupation, much opposition was anticipated. A majority of the owners, however, believed that the removal of the obstructions would make a better street and that their property would be more valuable without them, and when the work of their removal was completed, these expectations were so fully realized that the same treatment was extended northwardly to Central Park. Since then, the same policy has been adopted with respect to other important streets, including the narrow streets in the office building section of lower Manhattan. (Fig. 16.)

The right of the city to control and prevent the private occupation of its public streets is so obvious that it can scarcely be questioned, but the modern idea that the obligation of the city to its citizens is much more comprehensive and extends to the use which may be made of the property outside the street lines and which is actually owned by individuals, is not so generally accepted on the part of the owners of real estate, although regulations affecting the use of private property are now becoming quite general. The most common regulations of this kind are those affecting the arrangement and height of buildings. The most obviously necessary are those governing the proportion of lots which may be built upon and the arrangement of the buildings and open spaces, as these are essential to good sanitation and decent living. While ordinances of this kind vary so greatly that those of a great number of cities cannot be compared and classified, a few typical instances will be given. The greatest number of cities for which such regulations have been adopted are in Germany and they are there found to be more complex and varied than in any other country. They are applied in connection with the zoning system so frequently adopted by German cities, and which was first ad-

Fig. 16. Views of a street in New York before and after the removal of sidewalk encroachments.

vocated by Baumeister in the Seventies, but not actually put in force anywhere until in 1884 in Altona, when the famous Dr. Franz Adickes was Mayor of that city. In 1891 Adickes, who had meanwhile become the chief executive of Frankfort-on-the Main, introduced it there, and it was soon taken up by the German and Scandinavian cities. The older or inner city is naturally the first zone, where the highest buildings are allowed and where buildings in solid blocks are also permitted. Outside of this inner city, there are other zones in which the allowable height of buildings and the proportion of the plot which may be covered progressively diminish. In some German cities the effort to adapt buildings to special conditions has resulted in a great number of small districts, some of which may relate to a single street or to several city blocks.*

In Berlin the proportion of any lot which may be built upon depends upon the area of the lot and its location. For all lots up to 32 meters in depth, the regulations are similar for all portions of the city, both within and without the former walls; while for lots more than 32 meters in depth there is a difference in the regulation for the areas within and without the old walls. For the purpose of computing the portion which may be built upon, the lot is divided into strips or zones, the first of which extends from the building line to a depth of 6 meters, the second from the 6 meter line to a depth of 32 meters from the building line. On this first strip the entire area may be covered. On the second strip 7/10 of the area may be covered, while if the lot is deeper than 32 meters, 6/10 of the area back of the 32 meter line may be built upon if it lies inside the former city walls and 5/10 if without the old walls. In computing the area which may be occupied, the areas upon which building is permitted on the different strips or zones are added together, and the resulting total area may be occupied by buildings without regard to the proportion of the area occupied on any one of the strips.

In Dusseldorf there are five zones for which the heights of buildings are fixed, but in each zone there are from two to five classes for each of which the proportion of the lot which may

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* See report of Mr. F. B. Williams on "The German Zone Building Regulations" made to the Heights of Buildings Commission, New York, 1913.

be built upon is prescribed. In zone one there are three classes, in one of which two-thirds the lot may be covered, in another one-half if there are rear buildings, and in the third three-fourths provided the buildings are not more than ten meters or two stories in height. In the second zone, there are also three classes, in one of which one-half may be covered by buildings, in another 4/10 if there are rear buildings, and in the third 6/10 for buildings accommodating from one to four families or even more than four families if there are not more than two apartments on each floor. The third, fourth and fifth zones have two, five and three classes respectively, the proportion of the lots which may be covered being gradually decreased until in some cases not more than 3/10 of the lot may be built upon.

In Leipzig the proportion of the lot which must be left free of buildings is indirectly fixed by the regulation that the rear wall of a building may not be higher than the width of the courtyard. If such a regulation were applied to the typical American building lot with a depth of 100 ft., a building 50 ft. or four stories high could occupy only one-half of the lot area, even if carried out to the street line, while a building 75 ft. or six stories in height could occupy only one-quarter of the lot. The regulations in other German cities vary greatly but the foregoing examples will indicate the great detail in which they have been worked out in order to prevent a too intensive use of the land and an irregular or ragged appearance of the street. Each city appears to have worked out its solution of the problem in a different way, and the fact that the regulations are respected and followed without question indicates the acceptance of the principle that the citizen must in the public interest submit to these limitations upon the free use of his property. (Fig. 17.)

In Great Britain the regulations governing the proportion of the lot which must be left free are less precise and there is a greater similarity between those in force in different cities. In Birmingham the by-laws provide that all new dwellings shall be so erected as to leave in the rear an open space having an aggregate area of not less than 300 sq. ft., which shall be free from any structure above the ground level except water-closets, earth-closets or ash pits. In Sheffield the open space

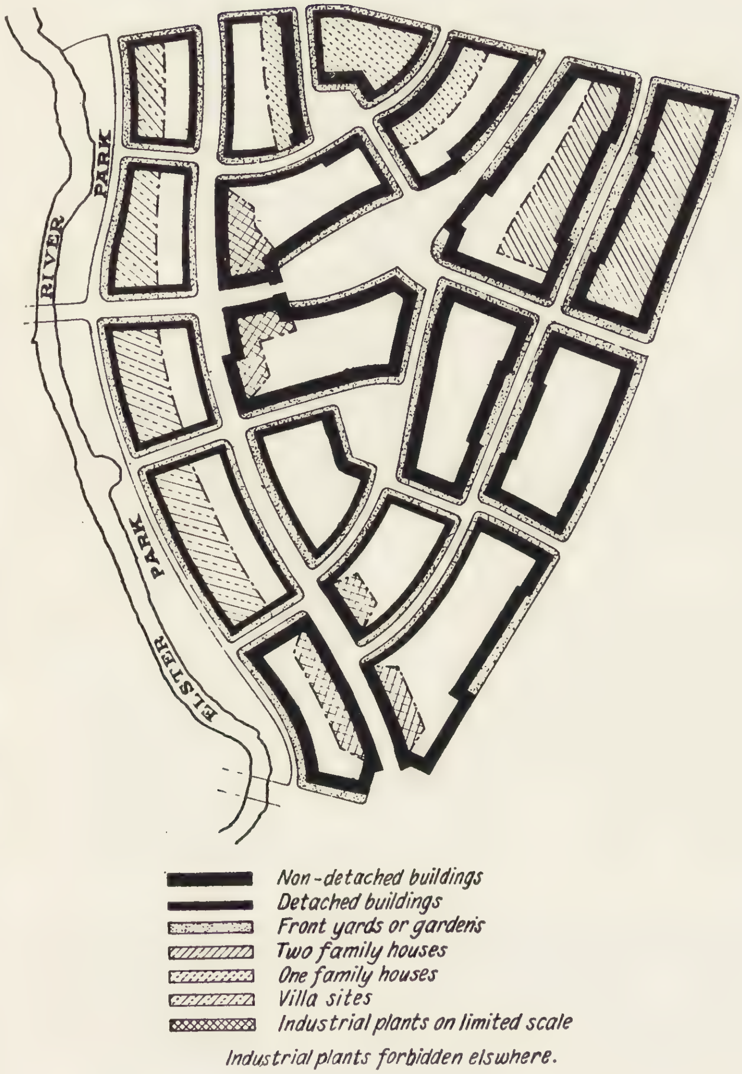

Fig. 17. Typical plan showing the regulations governing the character of buildings and the purposes for which they may be used which are imposed upon specific areas by the city of Leipzig.

in the rear of all dwellings must have an aggregate area of not less than 150 sq. ft. for buildings 15 ft. in height; 200 sq. ft. for a height of 25 ft.; 250 sq. ft. for a height of 35 ft., and 300 sq. ft. if the height is more than 35 ft., the height in all cases being measured to a point half way up the main roof.

In the United States, some cities have much more drastic regulations than others concerning the portion of the lots which may be built upon, but in no cases have they been worked out in such great detail as in Germany. As the laws and ordinances governing the open spaces are found in the city building codes, the health regulations, the factory and labor laws, and the city ordinances, they vary as greatly as do those of the German cities but do not appear to have the common underlying principles which are apparent in those of that country. In New York, dwelling houses accommodating not more than two families may cover 90% of the lot; hotels may occupy 90% of interior and 95% of corner lots above the second floor, but for each and every story over five, an additional 2½% of the lot area must be left free, so that at the fifteenth floor 35% of interior and 30% of corner lots must be left open. In the case of lodging houses, 35% of interior and 8% of corner lots must be left open. Office buildings, located on interior lots, may cover 90% of the lot at and above the second floor, while when they occupy corner lots, having an area of 3,000 sq. ft. or less, they may cover the entire lot. Tenement houses, or houses accommodating three or more families may cover 90% of corner lots having an area not more than 3,000 sq. ft., but if located on interior lots more than 90 ft., but not exceeding 105 ft. in depth, 30% of the lot area must remain uncovered.

In Chicago, tenement houses may not be built nearer than 10 ft. to the rear lot line, except that when the lot abuts upon a public alley the rear line of the building may be within 16 ft. of the opposite side of the alley. Rear buildings may be erected on a lot only on condition that the minimum distance between front and rear buildings is 10 ft., and, provided, however, that neither building exceeds one story in height, while five additional feet must be added to the minimum distance for every story more than one of the higher building on the lot, provided that a one-story building without basement and not

used for habitation may be placed on the rear of a lot containing a tenement house if a minimum distance of 10 ft. between buildings is maintained at every point. Courts and shafts are required which shall increase in size with the number of stories.

In Philadelphia, the only regulations governing the proportion of a lot which may be built upon is that no building for dwelling purposes shall have a frontage of less than 14 ft., and that at least 144 sq. ft. of the lot shall be left open.

Boston requires that where tenement houses have no open space on either side, they must have a yard the full width of the building at least 12 ft. in depth in the rear, and the building must not exceed 1,800 sq. ft. in area.

As already noted, regulations governing the portions of building plots which may be occupied are not likely to be opposed, as their necessity is obvious. Those which are designed to limit the height to which buildings may be carried are not always accepted as reasonable. Whether the rigid height limitations imposed in Continental and especially in German cities are altogether wise is a debatable question, but there appears lately to have been an impression that they have gone too far.

Berlin limits the height of buildings to the width of the street upon which they front, measured between the building lines, but there is a general regulation that the fronts of no buildings for habitation may exceed five stories in height although the roof may be carried to a greater height, provided no part of it projects beyond a line drawn at an angle of forty-five degrees back from the top of the front wall. In the case of rear buildings or buildings fronting upon inside courts, which are too common in this and other German cities, the limits of height are governed by the dimensions of the court, but their height may not exceed by more than 6 meters the width of the court on which they front and in no case may it exceed 22 meters.

Dusseldorf prescribes the following height limitations for each of the five zones already referred to into which the city is divided; zone one, 20 meters; zones two and three, 16 meters, or, where four stories are allowed, 20 meters; zone four, 16 meters; zone five, 13 meters, or, where three stories are allowed, 16 meters. In none of the zones, however, may the height of

buildings exceed the width of the streets upon which they abut. While the permissible height appears in some cases to be the same in different zones, this is due to the fact that the classes of buildings which govern the proportion of the lot area which may be built upon vary in each zone.

Leipzig simply provides that the height of buildings to the top of the main cornice may not exceed the width of the street upon which they front, while in the central portion of the city this height may not in any case exceed 22 meters.

While in Great Britain considerable attention has been paid to the securing of better housing conditions, the regulations affecting the height of buildings are quite meager, although limitations of this character are likely to be imposed in connection with the town planning schemes undertaken in accordance with the provisions of the general Town Planning Law of 1909. Edinburgh was the birthplace of the skyscraper but the high buildings in that city are located on the steep hillsides, and the Edinburgh people advance the argument that the proper place for towers or castles is on the hilltops where they can be seen to advantage and serve to accentuate the topography, but that when placed in the valleys their effect is to fill up the low places and detract from the beauty and dignity of the surrounding hills. Birmingham prohibits the erection of any building to a greater height than 100 ft., and Sheffield, since 1900, has limited the height of all new buildings to the width of the streets upon which they front, although provision appears to be made for carrying them to a greater height by special permission. Liverpool restricts the height of dwelling houses erected in new streets to the width between opposite buildings, but there is no limit to the height to which business buildings may be carried.

In the United States the difference in the regulations respecting permissible heights of buildings are at least as great as those affecting the required open spaces, and in most places the permissible height is so great as to present no real limitation. In New York, the labor, tenement house and other special laws, impose a virtual limit upon the height of certain classes of buildings, but there is no direct limit prescribed by statute or ordinance, excepting that which restricts buildings

used as dwellings to a height of one and a half times the width of the widest abutting street. Office buildings may be carried to any height, the tallest of this class yet erected rising to an elevation of 752 ft. above the street level. In Chicago, the height of tenements or dwelling houses may not exceed, by more than one-half, the width of the widest street on which they front, buildings which are set back from the street line being allowed to add the amount of such set-back to the street width in computing the allowable height. Fireproof buildings for office and business purposes may be carried to a height of 200 ft. above the sidewalk level, but prior to September 1, 1911, the maximum height for such buildings was 260 ft. Philadelphia has no law or ordinance whatever limiting building heights. In Boston, buildings in the business section may not exceed two and a half times the street width, and in no case may be more than 125 ft. high. In other parts of the city the limit of height is 80 ft., except that where but one side of a street is built upon or where a street is 80 ft. or more in width, the height may be 100 ft. Wooden dwellings are limited to three stories above the basement but may in no case be more than 45 feet above the street level.

Washington imposes a limit of 160 ft. for buildings on its very wide Pennsylvania Avenue; 20 ft. more than the street width on other business streets with a flat limit of 130 ft.; 85 ft. on residential streets, provided that on streets over 70 ft. wide the height may not exceed the street width minus 10 ft.; 60 ft. on streets from 60 to 70 ft. wide, and the street width where that width is less than 60 ft.

Charleston, New Orleans, Cleveland and Fort Wayne restrict building heights to two and a half times the width of the widest street with absolute limits of 125 ft. in Charleston, 160 ft. in New Orleans, and 200 ft. in Cleveland and Fort Wayne. Buffalo and Rochester limit the height to four times the average least dimension of the building, without specific limit in feet, while Toronto permits a height of five times the least dimension with an absolute limit of 130 ft.

A further and more radical step in the direction of regulating or restricting the use of property outside the street lines is the attempt to specify the uses to which the property may

be put. While for many years the conduct of noxious trades or occupations has been quite generally prohibited within city limits or has been restricted to certain districts where they would not affect values or discourage other use of neighboring property, the division of the entire city into districts, in each of which is prescribed the use to which private property may be put, is now claimed to be a reasonable exercise of the authority of the municipality. This plan of districting has been most fully developed in the German cities. The factory districts are naturally located along the lines of rail or water transportation, but their position with respect to the remainder of the city is often determined by the direction of prevailing winds, in order that smoke and odors may not become a nuisance in the business and residential districts.

A number of American cities have adopted district regulations, but none of them appears to have gone as far in this respect as Los Angeles. By an ordinance enacted in 1909, the entire city, with the exception of two suburbs, is divided into industrial and residential districts, there being twenty-five of the former and but one of the latter. This does not mean that there is one great unbroken area of the city devoted exclusively to residences. The industrial districts are widely scattered and the residential district includes the remaining area, so that it entirely surrounds many of the industrial districts and really covers the entire city, with limited areas taken out here and there. Further than this, there are within the residential districts not less than fifty-eight districts designated as "residence exceptions", in which business is permitted subject to certain conditions. The industrial districts vary greatly both in shape and size, the largest including an area of several square miles and the smallest consisting of one single lot. They are generally, however, confined to one part of the city, while their combined area is only about 1/10 that of the residential district. While one of the "residence exceptions" is about half a square mile in area, the others are small, covering not more than two city blocks. The restrictions within the districts are not sweeping. In most of the industrial districts all kinds of business and manufacturing are unrestricted, while certain specific kinds of business are excluded from the residential dis-

trict, but those not especially excluded are permitted in the "residence exceptions", although the owners of 60% of the neighboring property frontage must consent to the establishment of any "residence exception".

Seattle adopted a building code in 1913 which imposes restrictions upon the use to which property within the city may be put, while the State Legislature of Maryland has by special law regulated the use of property in certain parts of the city of Baltimore. The State of New York in 1913 authorized the municipal legislative body in any city of the second class, on petition of two-thirds of the property owners affected, to establish residential districts within which no buildings other than single or two-family dwellings may be erected, such restrictions to continue until a similar petition shall have been presented to and approved by the same body. In 1912, the Massachusetts Legislature so amended the general municipal law as to permit any city or town in the state, except Boston which is covered by special acts, to regulate the height, area, location and use of buildings and other structures within the whole or any defined part of its limits for the prevention of fire and the preservation of life, health and morals, excepting, however, bridges, quays, wharves and structures owned or occupied by the National or State Government. Minnesota, in 1913, authorized the cities of Minneapolis, St. Paul and Duluth, to establish residential and industrial districts by two-thirds vote of the municipal legislative bodies when petitioned for by a majority of the property owners in any proposed district. Authority is given to classify the various industries and to restrict each class to a definite and limited area, while upon a similar majority petition the original restrictions may be set aside or an industrial district may be changed to a residential district or vice versa. Minneapolis has availed herself of this authority and has created certain industrial and residential districts. Wisconsin also in 1913 conferred quite similar powers upon eight of the principal cities of that state, the demand for which powers was indicated by the fact that the Common Council of the city of Milwaukee some months before the enactment of the state law adopted an ordinance establishing a business section and prohibiting certain industries anywhere within the

corporate limits. The Provincial Legislature of Ontario, Canada, has authorized the councils of cities having a population of more than 100,000 to enact by-laws restricting the erection of buildings of certain classes to designated parts of the city; and Toronto, acting under the provisions of this law, has prescribed the use to which property may be put in a considerable portion of the city. Under this enactment apartment houses and garages are excluded from most of the residential streets.

It will be seen that the ideas that the municipal authorities have a distinct responsibility for the manner in which cities shall develop, that the right of the general public to protection from unsightly and offensive development must be respected, and that the individual property owner is entitled to a guarantee of the permanence of the character of the district in which he has located his home or his business, is constantly becoming more generally recognized, and this tendency must be taken into account by those responsible for the planning of cities.

SUBDIVISION INTO BLOCKS AND LOTS.

It might naturally be assumed that the size and shape of blocks and of the individual building plots into which they are divided would be controlled by the street plan which may be worked out for the area lying between the streets of secondary importance. As a matter of fact, the sizes of blocks and of lots has become so standardized, especially in cities of the United States, that they are likely to control the street layout and even to determine the distance between the principal streets. This standardization has been unfortunate in its effects, and has tended to prevent the most successful treatment of the smaller subdivisions which go to make up a great city. The building plot of 100 ft. in depth has become a habit in most cities and seems to persist without regard to its adaptability to either general or special conditions. Having become a habit in real estate development, it is adopted quite generally without careful study of its effect upon the possibilities of economical development or social conditions. In many cities the standard building plot is 20 or 25 ft. in width by 100 ft. in depth. The width may vary in different parts of the city but the depth

is usually constant. If an owner desires a larger plot he buys several of these units, but the buildings and building sites, with very few exceptions, have frontages which are multiples of this standard lot width and only in cases where they extend through the block from street to street is their depth more than 100 ft. This lot depth prevails alike in commercial, manufacturing and residential districts, whether the last named be devoted to costly detached houses, to compactly built tenements or to small houses designed for those of small incomes. In any case, the number of square feet to be acquired for each foot of frontage is the same, whether it is to be used by a great manufacturing or commercial concern, by a man of wealth for the erection of a fine mansion, or by a person of slender means who is obliged to borrow the money to provide a home and where the payment of interest on his mortgage taxes his resources to the utmost. The price per front foot will, of course, vary with the character of the neighborhood and with the width of the street and the cost of its improvement, but when the street width as well as the size of the lot is rigidly standardized the workman who desires a cheap home is under a serious and unfair handicap, and it matters not whether he tries to own his own home or, as in most cases, leases one; the burden runs with the land and if he does not pay in interest he pays in rent. The man of wealth can afford to pay for a large plot to accommodate his home. The poor man should have the opportunity to pay for as little land as will provide the home he wishes with an insurance of sufficient light and air about it to make that home decent and healthful. A cottage 25 or 30 ft. in depth does not need a lot 100 ft. deep to accommodate it. Why, then, should not the builder of such a cottage, whether it be for occupancy by the owner or for rent, be able to secure a lot of suitable size on which to place it? If the back yard abutting against a similar back yard on the next street were used as a garden the case might be different. But even where there is room for them, gardens are seldom made, and in most cases the reduction in the cost of the site would more than offset the value of the rear garden, especially where there is space for some planting in the front or where public gardens or small parks are provided in the neighborhood. With lots of less depth the street widths

could also be less, assuming always that the ordinances are such as will prevent the intensive development of shallow lots with compactly built tenements four stories or more in height. The result of the 20 or 25 by 100 ft. lot habit is the adoption of a standard block 200 ft. wide and 600 or 700 ft. long. In the preparation of street plans for territory within which local developments have been made years before and a number of houses have been erected, these are sometimes entirely ignored and obliterated by laying out over them a rigid rectangular street system, the carrying out of which will destroy many of these homes and will, under the pretext of benefit, impose upon them an expense which will be ruinous. (See Fig. 8.) The accompanying illustrations show a triangular area between bounding streets 100 ft. and 80 ft. in width, in one of which the subdivision into blocks and building plots is that generally prevailing and actually used in this case, which is taken from the plan of one of the eastern cities of the United States. (Figs. 18 and 19.) The streets are simply a continuation of a rectangular system covering the entire territory surrounding the particular area under consideration. The development contemplated is evidently one of detached houses for one or two families. Streets 60 ft. in width are separated by blocks 200 ft. wide and these are crossed at right angles by streets 80 ft. in width about 700 ft. apart. The 60 ft. streets have, in accordance with the ordinance in force in this city, roadways of 30 ft., while the streets 80 ft. wide have roadways of 44 ft. In the alternative plan the streets are given a width of 40 and 50 ft. with roadways of 16 and 20 ft. respectively. The triangular area within the bounding streets is 24.93 acres. The cost of the land is estimated to be $3,000 an acre and the tract to be so nearly level that the slight amount of grading required is included in the cost of the paving.

Under the original plan 24% of the area is devoted to streets and 76% to lots. Under the alternative plan suggested 26% is given up to streets and 74% to lots in which latter, however, is included a small park slightly over half an acre in extent. In the original plan sidewalk pavements are all 5 ft. in width, in the alternative plan 4 ft. In the latter the amount of curbing will be 58% greater, of sidewalks 26% greater, of

sewers 97% greater, but the area of pavement will be 26% less. The entire cost of development under the two plans is about as follows:

	Original Plan	Alternative Plan
Cost of land	$ 74,970	$ 74,970
Curbing	2,919	4,625
Asphalt pavement	31,054	26,653
Cement walks	8,343	10,480
Sewers	4,954	9,360
Total	$122,060	$123,908
Or if water bound macadam is substituted for asphalt	$108,985	$113,528
Total number of plots	204	259
Average area of plots	4,041 sq ft	3,033 sq ft
Cost per plot with asphalt pavement	$ 598.33	$ 478.41
Cost per plot with macadam pavement	$ 533.75	$ 438.33

The saving to the purchaser of $120 a plot in case the streets are paved with asphalt and of $95 a plot in case they are paved with macadam will mean a great deal to him. The small neighborhood park will mean much to his family and the entire character of the neighborhood will be improved by reason of the fact that it will acquire a certain individuality which would be impossible if the improvement had been carried out in the conventional manner.

Other plans for subdivision of this same area might be suggested with plots of varying depth and frontage. Semi-detached houses might be provided for or larger architectural units containing from three to seven or more houses might be constructed with larger open spaces between these units. This plan is very popular in the development of so-called garden cities but its success will depend to a great extent upon the practicability of insuring the communal interest of all of the home owners in these open spaces, a problem which is somewhat difficult in the United States owing to the strong individualism which is so conspicuous in this country.

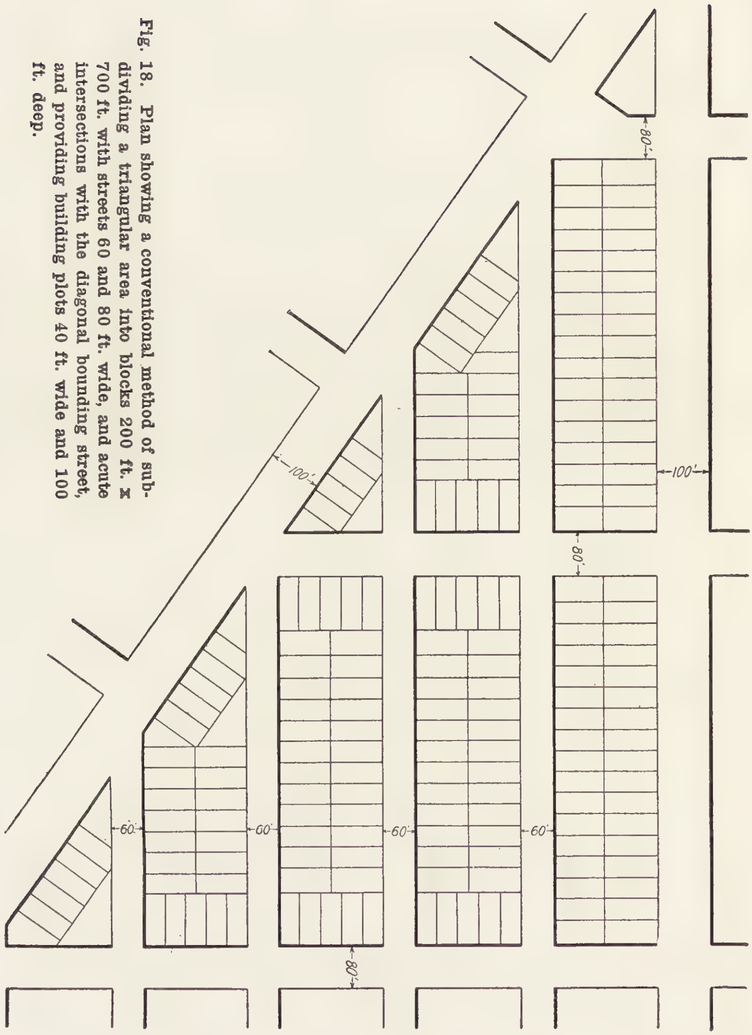

Fig. 18. Plan showing a conventional method of subdividing a triangular area into blocks 200 ft. x 700 ft. with streets 60 and 80 ft. wide, and acute intersections with the diagonal bounding street, and providing building plots 40 ft. wide and 100 ft. deep.

Fig. 19. Plan showing an alternative subdivision of the same triangular area illustrated in Fig. 18, by streets 40 ft. and 50 ft. in width with better intersections with the diagonal bounding street, providing for building plots 50 ft. wide and 60 ft. deep and a small neighborhood park.

FINANCING A CITY PLAN.

The development of a proper city plan is a slow process requiring years of painstaking work, but to carry it out physically will require much more time. The work must be done progressively as needed and it is of the utmost importance that such work should be sanely financed. There are several ways in which the cost of improvements included in the plan can be met:—by direct assessment upon the property which will be benefited by each particular improvement, by making the expense a general city charge, or by a combination of the two methods. When the city pays all or a part of the cost, the funds for the purpose must be raised in the annual tax levy or they must be borrowed; that is, the city must use either its cash or its credit. Many European cities have large revenues derived from profitable enterprises in which they have engaged and in some cases from land speculation. Such municipal ventures are rare in American cities and are still regarded with suspicion, and the only recourse of these cities is to the method of direct assessment, general taxation, or the use of their credit which is really the same thing as general taxation extended over a term of years.

Conditions in different cities, in the several parts of the same city, and at different stages of its growth and development, vary so greatly that the same methods of financing will not be applicable to all cases. In the small town,—and no town is so small that it does not need a plan,—the creation of a public square about which or in which the chief buildings including, perhaps, the churches are to be grouped is of general interest and benefit to the entire community. All public activities and even recreation and amusement will center there, and it will be conceded that the town itself should properly pay the expense. The most valuable property will be that fronting upon this square, so that if its creation will result in special benefit to the surrounding property that property will bear a correspondingly large burden. If the main street of the town needs widening, straightening or extending, the benefit will again apply to the entire community. But the town grows and becomes a city; other main streets must be provided; other centers of activity or recreation are needed. These new proj-

ects will still result in some general benefit but in a large measure of special benefit. The effect upon the property in their neighborhood will be proportionately greater than in the case of the first village green or town square. The entire community will doubtless feel the benefit of the new improvement but in less degree, as it tends to create a new center and diffuse rather than concentrate business and other activities. The town can still afford to contribute towards the expense, but the fair share to be assumed by it will be less in proportion to the amount of special benefit resulting to the particular locality. The ability of the town or city to contribute towards the expense of such undertakings will vary in different cases, depending upon the other burdens which it may have assumed or to which it may have subjected its credit, depending upon whether the city is deriving substantial revenue from privileges granted to public service or other corporations or individuals, depending upon whether it is conducting certain activities at a profit or whether they are being conducted at a loss for the benefit of the public using them, and depending especially upon whether the city has already borrowed to such an extent that an issue of further obligations would be likely to impair its credit. Again it remains for the town or city to determine if it is to pay all or a portion of the cost of any particular improvement and, if its credit is such that it can borrow the necessary funds, whether it will issue its bonds for a long term of years or whether it will carry out the improvement on a cash basis by providing for it in one or more tax levies or by short term bonds which will be retired soon after the completion of the work.

A large city is really a group of small towns or small cities which have grown together. While there are certain great projects that are commonly deemed to be of general interest, there are few which do not involve some special benefit to a particular locality. If a new park is to be created, the property in its immediate vicinity will acquire a certain fixed character and its value will be substantially increased. If a new and important public building is to be erected, there will be much interest in the selection of the site, and as soon as it is determined, it will have a marked influence upon the property

in its neighborhood, and it would not be difficult to give instances where, before the building was completed, the value of the surrounding property had at least doubled, especially if the public building is surrounded by considerable open space. If the city were, as some of our great cities now do, to construct a new rapid transit line bringing hitherto vacant lots within easy access of its business center, or if it were to provide a new waterway permitting docks and basins to be created in hitherto inaccessible swamps the effect upon these suburban lots and useless swamps can readily be foreseen.

If the property in the neighborhood of the new park, the new public building, the new rapid transit line or the new waterway, is to be increased in value by some act of the city, and if the owners of this property are to be enriched by this act, is it fair or just that these owners shall contribute no more per unit of assessed value towards the cost of the improvement which is to enrich them than do the owners of other property more slightly, if at all, affected? To determine the precise amount of benefit will be well nigh impossible, but the recognition of the fact of the benefit and of the obligation to pay a special share of the cost in return for that benefit, seems only a question of elementary justice. In the case of local streets the purpose of which is simply to furnish light, air and access to the abutting property, that property could fairly be required to pay the entire cost of the acquisition and improvement of the street. When a highway is given a more generous width in the expectation that it will be called upon to accommodate a certain amount of through traffic, the benefit is more general and the assessment area in such a case may be extended to a line midway between it and the next street of more than residential width. The major part of the expense should, however, be confined to the abutting property so that the cost to it shall be somewhat more than that of the narrower street. In the case of arterial thoroughfares, or in the case of the first street to be opened through an undeveloped territory, the effect of which will be to give access to and stimulate the development of a large district, the area of benefit will be correspondingly enlarged. Again in the case of thoroughfares of exceptional width which it is proposed to treat as boulevards or

parkways, the entire city or metropolitan district will be substantially benefited and should bear a portion of the expense. In the case of street widenings or the cutting of new streets through built-up sections, the local benefit is less marked though it will always follow. The mere fact that a widening or extension is required to accommodate traffic is conclusive evidence that the street has assumed more than local importance. The width of the road as widened is not an index of its local or general importance. There may be cases where the opening up of a new street of a width commonly given to local streets and extending for a very short distance would, on account of its strategic position, be of great general and of little local benefit. It is quite apparent that the relative local, district or general benefit resulting from any street or other improvement can be determined neither by its dimensions nor its cost. An improvement involving the expenditure of one million dollars in one part of the city may be more distinctly local in its beneficial effect than one costing fifty thousand dollars in another section. While no definite rule can be adopted to govern the distribution of assessments representing the local, district or general benefit, it should be possible to prescribe a method of determining the amount and extent of the local benefit, particularly in the case of new streets, boulevards and parks. Let us assume that 60 ft. is the maximum width required for a local street. Then the entire cost of acquiring and improving all streets 60 ft. or less in width may properly be placed upon the property within a half block on either side of the street. In the case of wider streets that proportion of the cost represented by the ratio which 60 ft. plus 25% of the excess over 60 ft. bears to the width of the street would probably be an equitable proportion to assess upon the local district. Up to a certain limit property fronting on a wide street is more valuable; on the other hand, after a street reaches a certain width, additional width will not involve additional benefit. It may be assumed that the share of the expense which would be equivalent to paying for a street 80 ft. wide should represent the limit of local assessment. This limit would be reached under the proposed rule when the street becomes 140 ft. wide. The percentages of cost which would be locally assessed would,

therefore, be as follows for various street widths: 60 ft. and less, 100%; 70 ft., 89.3%; 80 ft., 81.25%; 90 ft., 75%; 100 ft., 70%; 150 ft., 53.3%; 200 ft., 40%.

In the case of street widenings involving the destruction of buildings, the same general principles might be adopted as in the case of new streets but they should apply to the land values only. If the street were less than 60 ft. wide the proportion of expense for the additional land in order to make it 60 ft. would be assessed upon the half block on each side, while for all excess over 60 ft. the same rule already proposed could be adopted. For instance, if a street 50 ft. wide were to be widened to 80 ft., involving the acquisition of 30 ft. of additional property, the first 10 ft. required to make it 60 ft. wide and 25% of the 20 ft. over 60 ft., a total of 15 ft. or one-half the cost of the additional land to be taken might be assessed locally, the expense involved in damage to buildings being included in the district assessment or in the general assessment if the improvement is of sufficient importance to involve general benefit.

In the case of parks the problem is more difficult, the amount of local assessment and the extent of the area of local benefit being determined by the size and shape of the park and facility of access to it from other parts of the city. In any case, no rule should be adopted until it has been carefully tested and it has been demonstrated that the assessment levied in accordance with it will constantly decrease as the distance from the improvement increases. A curve to determine the distribution of the assessment after the limits of the district have been decided has been proposed by Mr. Arthur S. Tuttle, Deputy Chief Engineer of the Board of Estimate and Apportionment of New York City, in accordance with which about 32.5% of the assessment would be placed upon the first 10% of the distance to the outer limit of the area of benefit, 55% upon the first 25%, and 80% upon the district extending half way to the outer boundary of the area of benefit.* (Fig. 20.)

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* See "Paying the Bills for City Planning", Proceedings of Fourth National Conference on City Planning, Boston, 1912.

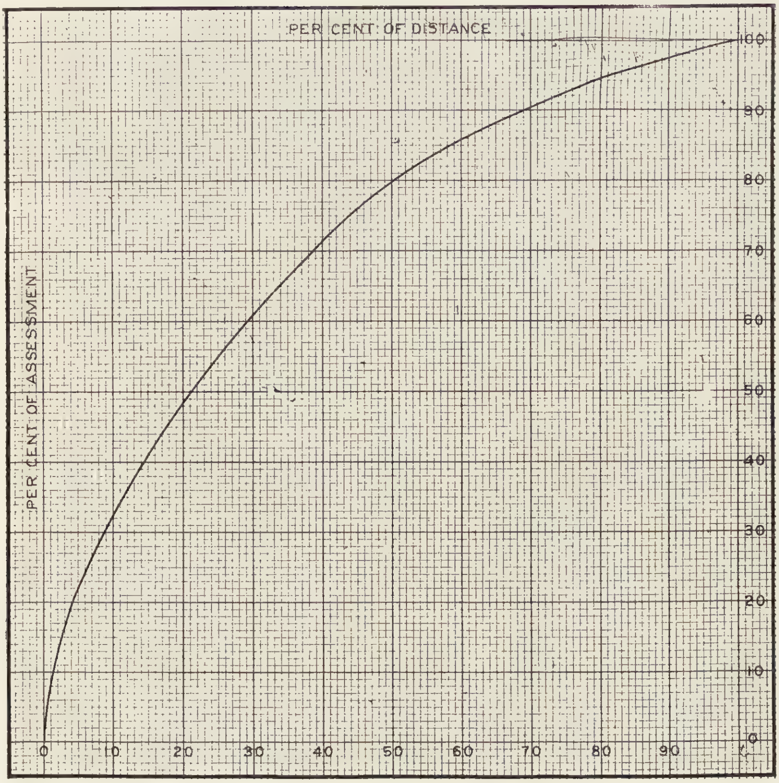

Fig. 20. Diagram showing a method of grading assessments for benefit according to the distance from the street or park to be acquired or improved.

CITY PLANNING LEGISLATION.

Cities of Continental Europe, especially those of Germany, have far broader powers than have those of the United States or Great Britain. It may be generally stated that the former can do almost anything not forbidden by law, while the latter can do only those things which are permitted or directed by general or special enabling acts. It is not, or at least it was not until very recently, unusual for cities in the United States to be obliged to go to the State Legislature for permission to make any changes in the city plan such as a change in the lines of a street, the establishment of a park, or, in some cases, the modification of such details as the widths of roadways and side-

walks. During recent years there has been a disposition to grant to cities a far larger measure of home rule, municipal legislative bodies being authorized to prepare plans for future development and to modify such plans, once adopted, in all their details. The most conspicuous piece of city planning legislation is probably the British Town Planning Act of 1909. Its purpose was constructive in that it was designed to prevent bad development in the future rather than the correction of past mistakes. It is administered by the Local Government Board which body is given very unusual powers which were formerly exercised only by Parliament itself. This board may authorize a local authority to prepare a town planning scheme if the board is satisfied that there is a reasonable need for such a plan. A scheme proposed by any local authority cannot become effective unless it shall first have been approved by the Local Government Board, which may refuse its approval except with such modifications and subject to such conditions as it may see fit to impose. The Local Government Board is authorized to prescribe provisions for carrying out the general objects of town planning schemes, these objects being given in the widest terms in a schedule which is a part of the act, including the laying out and improvement of streets and roads and the closing or deflection of existing highways, the erection of buildings and other structures, the provision of open spaces both private and public, the preservation of objects of historical interest or natural beauty, sewerage, drainage and sewage disposal, lighting, water supply, the disposal of land acquired by local authorities, the making of agreements by local authorities with owners, the limitation of time for the operation of the scheme, and the imposition upon land whose value is increased by the operation of a scheme, the sum to be paid on account of that increase in value.

The Province of Alberta, Canada, in 1913, enacted a town planning law which follows generally the British law of 1909 but goes somewhat further in some respects, notably in authorizing a city to appropriate one-half of the increase in the value of any land caused by the carrying out of a planning scheme, a recognition of the principle of the unearned increment tax so commonly exacted in Germany. The Conserva-

tion Commission of Canada has drafted a general Town Planning Act to apply to any of the Provinces of the Dominion which may adopt it. This proposed act is, in its general provisions, quite similar to the Alberta act, although the machinery for carrying it into effect is somewhat different.

The State of New Jersey, in 1913, enacted a law providing that the Mayor of any city of the first-class may appoint a City Planning Commission, while any commissions already existing shall be continued but with the powers and duties which are conferred by the act upon commissions which may be created under it. Among the provisions of this act is one requiring that all plats or replats of land within the city limits must be submitted to this commission before they are approved, although approval by the commission does not seem to be required. The State of New York also enacted city planning legislation in 1913, this act authorizing any city or incorporated village to create a city or village planning commission. There are two conspicuous features of this act, one providing that the commission may cause a map or maps to be made not only of the city or village or of any portion of it, but of land outside the limits of the city or village which may be so near or so closely related that in the opinion of the commission it should be so mapped. The other provision is that ordinances may be adopted forbidding the receipt for record or filing in any office of any plan or plat showing the layout of any highway or street upon private property or of building lines in connection with such highway until a copy of the plan shall have been filed with the commission and it shall have certified its approval thereon, such certificate of approval being regarded as a part of the record of the original instrument. Three cities in New York State have created commissions under the authority of this act. Thus far they are feeling their way and success will depend upon the good sense and sanity with which the powers entrusted to commissions of this sort are exercised. If the duly constituted city officers can be made to appreciate the opportunities presented to them to plan in a more farsighted way for future development and to avail themselves of the popular interest in this subject which now exists, it is quite possible that more substantial and more lasting results may be secured

through existing machinery than by means of special commissions created for the purpose, the members of which are not likely to feel the same degree of responsibility to the people as are their duly elected officers.

THE RESPONSIBILITY OF THE MUNICIPAL ENGINEER.

The author has attempted in the preceding pages to outline the salient points of city planning as understood in the United States and other countries at the present time. As stated in the beginning of the paper, the keenest interest in the subject has heretofore been shown by architects, landscape architects, artists, students of civic affairs, social workers, etc., while engineers appear to have been content to carry out the physical work of city planning along lines already laid down or, when called upon to make plans for future development, to adopt the conventional features followed by their predecessors. Engineers engaged in this particular class of municipal work have so long been accustomed to doing things when they are told, as they are told and because they are told by those whose function they have thought it to be to determine general plans and policies, that they are to a large degree responsible for the idea so generally prevalent that the chief work of the engineer is to carry out the ideas and policies of others. The exercise of vision and imagination on their part has too often been deemed a dangerous incursion into a field foreign to their proper activities; and yet the engineer is the first man on the ground in laying the foundations upon which our cities are to be built. He has been too prone to regard this preliminary work as a mere matter of surveying; more or less precise surveying, it may be, but he has been more intent upon the accuracy of his measurement of lines and angles and of his computation of areas than upon the larger problem of providing for the orderly and sightly development of the city. His eyes have been so closely fixed upon the drawing board that he has seldom looked up to catch a vision of the great city that is to come,—the complex organism known as the modern city with its varied activities, its difficult social problems, its ugliness or its beauty, its awkwardness or its convenience, its capacity to debase or to elevate

its citizens. Every blunder that he makes will afford an opportunity for someone else to win applause for a plan to correct it through large expenditure of public funds. It often seems as if the admiration excited by what are commonly called city planning projects are in direct proportion to the amount of destruction of existing improvements and the extent of the disarrangement of the existing plan which may be involved. If you are going to dream, we are told, dream a big dream and the people will look and admire; but these big dreams appear always to involve the spectacular making over of a big city and rarely the planning of a city not yet come into being or even of a city which is just beginning to give promise of rapid growth, although still in a formative state. Planning of this latter kind will not bring applause; genius devoted to such work will not win prompt recognition. The merits of such a constructive plan may not be appreciated during the lifetime of the man responsible for it. L'Enfant died many years before his plan for Washington was realized to be anything more than a fanciful sketch.

The author does not envy the architect who offers an ingenious and effective solution of a difficulty caused by lack of foresight in city planning, but he deplores the fact that such blunders have been so commonly made by engineers and more particularly the fact that engineers are so inclined to go on repeating the same mistakes. The making of a comprehensive plan for the future development of a city or for correcting the obvious defects of an existing plan is no work for an expert who may be called in for a few weeks or months and who, it is fancied, may have an inspiration which will solve all the difficulties which are apparent. Acres of plans have been made in this way; they have been exhibited, admired, filed away and forgotten. The creation of a proper plan is more likely to be the result of years of patient work, and the men who did it will be forgotten before it is finally carried out. It is no one-man job and it is never actually finished. However carefully and skillfully the first plan may have been made, unforeseen changes will take place, new methods of transportation will be developed, new inventions will powerfully affect the social life of the community, and the plan, where still susceptible of change,

must be modified to meet these changed conditions. Comprehensive city planning can best be done by the regularly employed technical staff of the city, but the organization created for this purpose should be carefully selected. It should contain men who are familiar with the past history and traditions of the community and are in sympathy with them, but who can appreciate changing conditions and adapt the old to the new without destroying it. The work should be directed by men who do not think the exercise of imagination an engineering crime; men who are enthusiasts without being doctrinaires; men who are content to do their work well without hope of popular applause and who are willing to await the verdict as to their work which will be rendered by coming generations. They will not, however, be obliged to wait indefinitely for recognition if they manifest an intelligent interest in this subject and an appreciation of its importance. The work of planning as well as that of building a city is so obviously that of the engineer that he has but to reach out and take it. Other expert advice will be needed, that of the architect and the landscape architect; such advice should always be welcome and in some respects their judgment should be controlling. If the engineer does not assume this task and show his capacity for it, he will have no one but himself to blame if others take it away from him.

DISCUSSION

Mr. Child. **Mr. Stephen Child,*** M. Am. Soc. C. E. (by letter), desired to place especial emphasis on the following elements of the problem of city planning:

(1) Imagination, (2) the Home, (3) Need of new or revised administrative machinery, (4) Details.

Design involves definite art principles. Mr. Lewis calls this ''imagination'', the engineer's word for design or art; a term we have grown to avoid.

There must, however, be both imagination and coöperation. This inclusive, broader grasp differentiates the mere maker of plans for a city from the ''City Planner''. The American engineer has been too content to carry out the ideas and policies of others. In Europe, engineer, architect and sculptor co-labor for more beautiful and more livable civic conditions.

* Cons. Engr., San Francisco, Calif.

In the past, conservative men were naturally repelled by a movement whose early efforts toward civic beauty, inspired no doubt by the charm of the Chicago World's Fair of 1893, proposed gloriously extravagant civic centers, scenic boulevards and terraced river fronts. No real good was promoted by these fruitless dreams. In fact, true civic art, as expressed by Mr. F. L. Olmsted, Jr., recognizes that "the demands of beauty are, in large measure, identical with those of efficiency and economy and differ mainly in requiring closer approach to practical perfection, in the adaptation of means to ends, than is required to meet the merely economic standards. So far as the demands of beauty can be distinguished from those of economy, the kind of beauty most to be sought in the planning of cities is that which results from seizing instinctively, with keen and sensitive appreciation, the limitless opportunities which present themselves in the course of the most rigorous practical solution of any problem—for a choice between decisions of substantially equal economic merit, but of widely differing aesthetic qualities. . . . Regard for beauty must neither follow after regard for the practical ends to be obtained nor precede it, but must inseparably accompany it." Mr. Child.

Mr. Child then called attention to the following elements in the problem of city planning:

(a) Recognition of the fact that the life of the city is the home, which must be wholesome, accessible, and agreeable.

(b) A civic survey—historical, social, economic, industrial, educational and engineering. A comprehensive grasp of the city's probable development must precede the "plan", a work governed by the laws of unity, variety, harmony and balance—as important in the design of a convenient and beautiful city as of a cathedral.

He desired to note the many elements in the problem which come within the purview of the engineer. Thus,

(c) Recognition of the future. A living organism, guided by a definite art purpose, includes inevitable growth in its ideal.

If home is first, all housing must be good. A city without a slum is no longer a dream, but a necessity, and building codes are of vital importance. The "Building Code" and "Model Tenement House Law" of New York, while helpful, are perhaps not altogether well suited to other communities—each must meet its own conditions.

Again, the existing cumbersome and complicated administrative machinery of most cities needs revision; for in the tangle of our many and varied commissions and departments, "general welfare", the American equivalent of the English "amenities", is lost. There are several reasons for the need of a city planning commission, such as the inability of any other to cover more than its own field, the twilight zones often left between separate city departments, and the feeling of jealousy that may prevail between departments, with its disregard for broader interests. Co-relation of all for the good of all should be the prime purpose of a city planning commission.

Mr. Child. Wherever it is feasible, as proven in New York City, it is advisable to utilize existing civic machinery. The framers of the present New York City Charter were prejudiced against the name, but their Board of Estimate and Apportionment is today a most effective city planning commission.

The organization and functions of city planning commissions must be adapted to local conditions. Recent enactments at Cleveland and Dayton, Ohio; the recommendations of a representative progressive committee of the Boston Chamber of Commerce; the laws of the State of California; and the book, ''Carrying Out the City Plan'' by Flavell Shurtleff and F. L. Olmsted, Jr., are all helpful.

He then called attention to certain details of the problem. Thus, a home, if wholesome, must be well built, provided with good water, sewers, drains, lighting facilities, and freed from noise and litter; if accessible, it must have well designed streets, walks and transit facilities; if agreeable, it should be enhanced by shade-trees and reserved planted areas, provided with well distributed and designed playgrounds, small and large parks and connecting parkways. These latter, while not primarily the engineer's concern, often vitally affect his drainage and sewerage problems.

In the all-important ''civic survey'', the data of his office are of inestimable value. The ''inevitable growth'' of our cities, so fully and effectively emphasized by Mr. Lewis, lays upon the engineer especially the responsibility of plans designed in advance of needs.

The municipal engineer has been scored for his adherence to uniformity: The engineer in many a modern city knows only straight lines and uniform gradients. Side-walks must always be so many inches from the lot line; trees must always be outside the side-walk and at a uniform distance from the curb—all regardless of topography and of vistas that are destroyed, or that might be called into existence but are not. Such an engineer attacks his urban problem with violence; the ''artist engineer'' woos nature caressingly. Why not an ''artist engineer''? There are many in Europe, a few in America.

Standardization and uniformity persist for several reasons: no imagination is required, and little thorough engineering training; such plans are easily described for deeds, and are inexpensive.

Topographical conditions usually determine ''residential districts''. Their needs are best met by:

(1) Relatively narrow streets, forty to fifty feet between property lines.

(2) Pavements, sixteen to twenty feet wide; side-walks, four or five feet; both, if carefully adjusted to topography, save construction expense and maintenance. Conditions vary with the type of pavement, arrangement of blocks and other factors, but in some instances careful figures show a needless pavement expense of three-quarters of a million dollars for each square mile of residential district.

Mr. Child.

(3) Side-walks, either above or below pavements—sometimes omitted, though designed for subsequent needs. The wide space between walk and pavement spares good trees, saves blasting interesting ledges, permits planting of trees, vines and shrubs and is self-sustaining, attractive and economical.

(4) Relatively steep grades, 5 to 8, even 10 percent, for roadways or walks assure quiet, by deflecting through traffic and heavy teaming.

(5) Opportunity for encroaching subsequently on planted areas, when traffic demands.

(6) All underground structures placed beneath the wide planting space or side-walk in duplicate. Galleries for these are proposed by Mr. Lewis and urged by Mr. L. A. Dumond of Chicago, who gives the following advantages:

(a) "It costs less to remove a cheap side-walk than an expensive pavement. Maintenance cost is lowered.

(b) "Utilities placed beneath the side-walk have a longer life than those beneath pavements, due to the absence of shock and vibrations from overhead traffic, settlement of earth and so on.

(c) "The interference of pedestrian traffic is negligible as compared with vehicular traffic and causes no economic loss.

(d) "The installation of subways is made considerably less expensive where no utilities have to be supported and maintained in service during construction.

(e) "Expensive pavements are not destroyed and their normal life reduced.

(f) "The absence of the large number of street man-holes and expensive special work is a real asset.

(g) "The expense of maintaining utilities being less, the municipality can obtain lower rates for the service furnished".

To these could be added, if placed under planting areas, the following:

(h) No expensive galleries are needed.

(i) It costs far less to remove sod or planting than either pavement or side-walk.

(j) Water and gas mains and electric-wire conduits, for one side only of a city block, need never be very large, dependent upon engineering data.

(k) When blocks are short and grades propitious, surface water drains may not be needed, paved gutters with catch-basins at or near corners being sufficient.

(l) Water mains and sewers, in cold climates, need not be so deep under sod as pavement to prevent freezing.

(m) The cost of service connections is greatly reduced.

(n) The flexibility of the scheme is of great advantage. In new districts, excellent pavements may be laid, the reserved areas planted and, when active building begins (sometimes months or years later)

Mr. Child. sewers, water and gas pipes and electric conduits are laid, meeting the demands as required.

(o) No money is buried in advance for water pipes and sewers, with their connections laid to the street line every twenty-five feet, as under old arrangements—often not used for years, some never.

(p) If slight settlements occur in repair trenches in these planted areas, there is neither danger to traffic nor damage.

These advantages go far to meet the great objection—expense of duplication. The method is furthermore an improvement upon placing such underground structures in reserved strips at the rear of lots. It removes a burdensome restriction, makes them more accessible and is far more flexible.

Alleyways are condemned; their convenience for service and pipe location is more than counterbalanced by their abuse, unless with rigid restrictions, which are difficult to maintain.

Regarding "Limitations": (1) Foresight should secure to the city easement rights in the strip between existing street and building lines, to facilitate future street widening. (2) Minimum zones should be provided, one side not an entire city block—conditions on the four streets often so different. (3) To be sustained by the courts, all restrictions must be based, not on art principles, but on public health, comfort or morals; and thus founded, are approved, even when involving the aesthetic principles which the imaginative City Planner, "The Artist Engineer", has maintained. This thought applies to ordinances aimed at the suppression of the billboard, smoke and other nuisances.

He agreed with Mr. Lewis' vigorous condemnation of "standardization" of lot and block. Depth of lot, length and width of block, should be designed to suit conditions. These are affected by the use or misuse of rear yards. A common use, either for children's playgrounds or allotment gardens, is often desirable.

The inherent characteristics of our cities should be perpetuated and enhanced. In Europe, particularly in Paris, this has been realized. The expression of a civic ideal has there created an organic unity. In America, these have more often met destruction; in San Francisco they were flagrantly sacrificed. The beauty of its "hundred hills" gave promise of enduring charm, had the spirit of these hills and valleys been sought rather than slain; may we save the remainder.

Further afield, the Engineer should coöperate with the City Planner and Landscape Architect, toward the attainment of attractive reservoirs, often very properly located in city parks. Strength is necessary for the well designed dam, but this may be relieved at either end by agreeable curves. The ugly rip-rap shores, the awkward straight lines or geometric curves and the barren slopes may be replaced by graceful, natural outlines, with gravelled beach-like shores—these with well chosen planting constitute an adornment to the park.

Mr. Chas. M. Gunn,† Mem. Am. Soc. M. E., referring to Mr. Child's discussion, desired to ask the following questions: Mr. Gunn.

1. Are sewers and conduits placed on both sides of the street beneath the sidewalk?

2. Does it not cost much more to have two sewers on each side than one in the center?

3. Has any difficulty been found in laying sewers under parking planted with trees?

4. In residential districts where the grades are steep, about 8%, which type of pavement, smooth, bitulithic or macadam, would you recommend?

Mr. Child replied to Mr. Gunn's questions as follows: Mr. Child.

1. Yes.

2. The choice depends upon conditions, and the balance of advantage must be determined by the engineer. The principal point is that the streets do not have to be turned up for repairs.

3. It is quite possible to dig around the trees or through the roots if necessary. If the joints are tight there is no danger of roots getting into the pipe.

4. I should prefer the bitulithic or macadam. The bitulithic pavement stands the wear.

Mr. Gunn then expressed the opinion that the bitulithic pavement becomes dangerous when it becomes wet. Mr. Gunn.

Mr. W. B. Bovyer,* Jun. Am. Soc. C. E., desired to ask the following questions: Mr. Bovyer.

1. Has any objection been found on the part of the property owners to manholes placed in the center of the sidewalk?

2. Has objection been found to the disagreeable odor?

Mr. Child answered Mr. Bovyer's questions as follows: Mr. Child.

1. He had never met with that objection and had laid several miles of sewers.

2. The question of odor is a matter of maintenance. The sewers must be flushed out.

Mr. M. M. O'Shaughnessy,** referring to Mr. Bovyer's question, pointed out that while Mr. Bovyer inferred that the sewer in the center of the street is less objectionable than on the side; nevertheless, connections to sewers on one side can be made the same as in the center. Mr. O'Shaughnessy.

Mr. C. H. Cheney,‡ referring to the sketch, noted that the sidewalk changed from one side of the street to the other. He called attention to a recent ordinance passed by the City Council of San Rafael, ordering a 5-foot sidewalk when two feet would have been sufficient. In other cities, for considerable area, sidewalks have been placed on one side of the street Mr. Cheney.

† Mech. Engr., San Francisco, Calif.

* Ass't City Engr., San Francisco, Calif.

** City Engr., San Francisco, Calif.

‡ Architect, San Francisco, Calif.

Mr. Cheney. only, and in such cases parties on both sides of the street have raised no objections to paying for the single sidewalk. If sidewalks are constructed according to the traffic requirements, a considerable saving could be made in the street work.

Mr. Bogue. **Mr. Virgil G. Bogue,*** M. Am. Soc. C. E. (by letter), considered it a promising indication that city planning has begun to attract more general attention in this country. Until within comparatively few years, interest in it had been confined largely to those who as owners or agents had had charge of the laying out of town and city property. Instances of their operations demonstrate the non-success of the gridiron plan in many cases and especially as applied to the slopes of a hilly town, where it is, after some years, seen to be detrimental to civic growth and prosperity, while, at the same time, development has gone too far to admit of much effective change, although something may still be done to ameliorate the situation.

In the future, city planning will often have to do with cities and towns already of considerable size, where it will be desired to overcome early faults, including those of the gridiron method. In outlying vacant environs, the problem is comparatively simple, but in areas already occupied by business and residential buildings, quite other conditions prevail, involving many practical difficulties. No matter how desirable arterial highways may be in such localities, their adoption means heavy expenditure and is often met by the active opposition of property owners. The question becomes a severely practical one which must be studied with care and good judgment, and the probability that an ideal solution can be reached is remote. A practically vacant town site ought to furnish conditions promising ideal results; but even here there are qualifications, and the plan of the arterial streets must often be modified by such considerations as proposed waterfront improvements, railroad facilities, the views of owners, and the like.

The most important element in city planning is the selection of arteries of traffic. When these have been determined, the laying out of new streets or the adjustment of those already existing to these arteries, with other details, will naturally follow.

In dealing with an existing town or city, the difficulties to be met in projecting new arterial streets are obvious. Property values, long established business locations, important street intersections, social and civic centers, existing routes of heavy traffic, must all be considered, and the resulting complications may be serious enough to become prohibitive over large areas. In all such cases it is necessary to proceed with the utmost care and good judgment and to confine the new arteries to locations that are feasible and reasonable. Of course, traffic congestion may justify radical treatment in the selection of a route or a plan involving large expenditure, provided it is effectual. Whenever practicable, the arterial highways should follow the lines of existing streets, but excessive grades or distances will quite generally render this impracticable,

* Cons. Engr., New York, N. Y.

Mr. Bogue.

excessive distance resulting from any attempt to follow these lines around large areas of the gridiron plan. The same may be said of parkways and boulevards which are to become a part of the park system.

The extension of arteries into the country beyond valuable areas is simple, but still largely affected by property values. The solution of the problems found in such localities is to be looked for in the study of the topography, in the seeking of lines of drainage or sometimes of ridge lines, although not infrequently the necessity arises of crossing from one drainage or ridge to another to secure the best average result. Whether the planning is in the built up or in the vacant areas of a town, the arterial streets must be accommodated more or less to the topography, and in order to obtain easy grades will generally be on curved lines.

Too many arteries should not be established. The object of an artery is to provide a street with easy grades and short distances between various sections of a town. A few grand highways of this class, if of sufficient width, will meet all the demands of a large city, the streets of the gridiron plan or of the park or garden plan, as the case may be, being connected therewith by suitable intersections, some of which should be made prominent.

The effective planning at and near Denny Hill, at Seattle, by the Engineering Department, under the direction of Reginald H. Thomson, who, at that time and for 18 or 20 years previous, had been City Engineer, consisted largely in the establishment of new street grades and some important readjustments of street alignment. The result was the complete transformation of a most important area. What appeared to be before that an insuperable obstacle to business extension was by this means overcome, and the result strikes everyone who saw Seattle in the old days and sees it now as one of the notable accomplishments of the times.

The construction cost of this work, as far as it has been already carried out, was serious; but we may consider this to have been counterbalanced by the greatly added facilitation of traffic, and by the increase of taxable values. In fact, we may safely say that without these improvements, Seattle could not have become the city it is and promises to be.

To a considerable extent as an outcome of this work, the Municipal Plans Commission, consisting of twenty-one members, was organized, under whose direction the preparation of the "Plan of Seattle" was undertaken by the writer (Mr. Bogue).

The first step in this work was an automobile reconnaissance of the streets and topography of the city and its environs, reaching to the Snohomish county line on the north, to Renton and Orillia on the south, to high ground east of Lake Washington on the east, and to Puget Sound on the west, covering an area sufficient to accommodate at least a million people.

Mr. Bogue.

This reconnaissance occupied the time of the writer, with an assistant, during six weeks. The information gained, supplemented by a study of the street grades and elevations, certain contour maps, and also the data gathered by two parties of engineers with full crews who were employed for several months, became the bases for the study and establishment of arterial streets or highways as described in the ''Plan''.

The Commission held frequent meetings, sometimes attended by a large number of interested citizens, at which colored wall maps on a large scale were submitted, and very full discussions followed. Since then a considerable beginning has been made in carrying out the ''Plan'', especially in the south part of the city and its environs, and in time, doubtless, much will be done in like manner towards the north.

It will be seen that city planning cannot be effected in an offhand manner, or by mere inspiration. Imaginative effort is helpful, but satisfactory results may be obtained only by thought and application. The location of arterial streets calls for much the same study and talent as are needed in the location of a railroad. Several alternative routes may suggest themselves, and these must be compared each with the other in regard to the best present and future service to the public.

Paper No. 51

LONDON TRAFFIC IN 1913.

By

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London, England.

INTRODUCTORY.

London is the largest aggregation of population in the World which looks to a common centre of civic life. It is only possible for such an aggregation to occur where there are adequate traffic facilities. The traffic facilities link up and bind together the wide spread areas over which the population is scattered to make its homes. Not only must these be adequate, but they must afford a public service efficient in point of time occupied for the journey and economical in point of charge for the fare. These are the two factors that control the growth.

To secure a healthful standard of life, a population should occupy large tracts of land so that the buildings may be interspersed with pleasant spaces of country. To ensure an active and progressive life, a population must be brought closely together for the exchange and sharpening of thought and the sharing of a common weal. The realisation of both these essential conditions depends upon the traffic system. It, therefore, should rank very high among public services.

I. THE SIZE OF LONDON.

1. The Central Area.

At the heart of London are the ancient cities of London proper and of Westminster. The area they occupy is only small, being a square mile for the one and some four square miles for the other, and in this extent are included the Royal Parks, about a square mile in themselves. Except for these parks, these areas are almost wholly built over. Yet their permanent population is only small. In the City of London, it amounts to 19,657 persons or 29 to the acre, and in Westminster, chiefly congregated

in blocks of residential flats, to 160,261 persons, or, together, 179,918, giving a density of 56 persons to the acre. Their day populations, however, far exceed their night populations. For the City of London, this has been ascertained by a special census, and was found to amount to 364,061 persons, or an influx of 344,404. For the City of Westminster, no corresponding figure is available, but as the proportion must be somewhat similar, for the business section at least, the influx must, in this case, approach a million folk daily.

2. The Administrative County.

Around this core lies the Administrative County of London, consisting of 27 Metropolitan Boroughs, with an added area of 112 square miles. Certain districts in the southeast corner of this area are only ill developed, otherwise, the whole of it is fully built over or dedicated to the public use. The population numbers 4,341,767, giving a density of just over 60 persons per acre on the average. Upon analysis, this average is found to be made up from densities varying from 170 to the acre in Southwark, Shoreditch and Bethnal Green, to 37 to the acre in Hampstead, due to the liberal provision of open space;—25 to the acre in Greenwich, 23 in Lewisham and 15 in Woolwich,—the southeastern districts to which reference has just been made.

3. Greater London.

Then, around the County of London lies a further ring comprising 9 municipal boroughs, once small independent towns, and 62 urban districts slowly growing round them and building them in, with parts too, of some 14 rural districts. These added to London County constitute what is known as Greater London. The area of this ring is 576 square miles and the population 2,729,673, giving a density of about 7½ persons per acre, varying downwards from a density of 62 in the Borough of West Ham to densities of less than 1 person per acre in the rural districts. Summing up the figures to this point, Greater London comprises 693 square miles of country and a total population of 7,251,358 persons, with an average density of 16½ persons to the acre.

4. The Outer Suburban Ring.

Out and beyond this again are districts with populations clustering round the stations of the railways which run out from

London in long lines, yet looking towards London for their work and interests. These districts are together known as the Outer Suburban Ring. This has an area of 2115 square miles and a population of 1,219,788 persons, or less than 1 to the acre. It is, therefore, merely sparsely populated from the point of view of the average; but the inhabitants are drawn up in little local centres, such as the townships of St. Albans with 18 to the acre, of Gravesend with 22, Rickmansworth with 11. Adding the figures for this part on to Greater London the grand total of the persons centred on London, or affected by its existence, amounts to 8,471,146.

II. TRAFFIC FACILITIES IN LONDON.

It is not easy to give a picture of the traffic facilities of London that will enable a stranger to realise the extent or effectiveness of them.

1. Railway Stations.

As to the railways, the most useful index is the number of their stations. In the central area, the Cities of London and Westminster, there are 38 separate underground stations upon the local urban railways. In the Administrative County of London, there are 147 separate stations, not counting twice over the stations which serve two or more underground lines, and upon the whole local urban system of railways there are 180 stations in all, shewing that 33 lie outside the County. This system of railways consists of 8 independent lines grouped together under two controls, one with 6 and a route mileage of 61½ miles, and one with 2 and a route mileage of 28 miles.

The Main Line or Trunk Railways serving London are 9 in number with 16 terminal stations. These railways have 159 stations within the Administrative County, 251 within the boundaries of Greater London and 164 more in the Outer Suburban Ring, or altogether 574 stations. The most noticeable feature of the Main Line stations is the fact that all the terminals are detached and, with the exception of Charing Cross, not located at a really immediate traffic centre. This feature is of some consequence in the consideration of the problems arising out of the operation of London traffic. Each Main Line railway is in the hands of a separate company (leaving

over some short connecting lines held by other separate companies but under the joint control of the Main Line railways interested in their traffic). There are no agreements between these companies affecting the passenger traffic of London, so that each is free to pursue its own policy in this respect.

2. Tramway Routes.

The tramway, or street railway, system is practically excluded from the central area, for reasons of convenience based on the unsuitability of the narrow thoroughfares of the City and on the congested character of the street traffic in the important thoroughfares of the west end. In this central area there are only 2½ miles of tramway route.

The tramway authority for London County is the County Council. This authority owns and operates 145 miles of tramway, roughly divided into two systems: One north of the Thames and one, the larger of the two, south of the Thames. These systems are connected by a single route across the central area, built in subway, and only capable of being operated by single deck cars.

Outside the London County, there are various authorities, and they may be divided into two classes: First, 10 local authorities owning and operating between them 78 miles of tramways and 3 private companies, acting as licensees for the local authorities, owning and operating 123 miles of tramways. All these tramways are in Greater London, and there are no tramways, in the Outer Suburban Ring that enter London. The interurban express tramway is not known. The best index to the traffic carried by all these tramways is the number of passenger cars which they own. It is 2,780. The size of a tramcar varies from 36 seats to 78 seats, but the most usual size will average 74 seats.

3. Motor Omnibuses.

Lastly there is the motor-bus industry. This has spread a net-work of routes all over the area covered by Greater London and to parts beyond in the Outer Suburban Ring. It reaches points as far distant from Charing Cross, the accepted centre, as Reigate on the south, 22½ miles; Maidenhead on the west, 31½ miles; St. Albans on the north, 22 miles; and Romford on the east, 14½ miles, with regular daily services. The maximum extension which it has reached up to date, comprises 551 miles

of roadway worked by 127 routes, or services, on Weekdays and 609 miles of roadway worked by 122 routes on Sundays. The operation of the system is practically under one control, although the ownership is divided among eight companies. The number of motor-buses outside this control is negligible, being 18 in number, owned by three separate companies. The number controlled was, in July, 1914, 3,525 total stock, with 3,477 working on Whit-Monday, 1914, the day of maximum movement. A motor-bus seats 34 passengers, 16 inside and 18 on top.

With the outbreak of War, the fleet of buses has been broken in upon to perform services of a strange kind, as supply waggons, ambulances, gun-platforms, ammunition waggons, as well as the carriage of troops, so that the present situation is far from normal.

III. THE CONTROL AND REGULATION OF LONDON TRAFFIC.

Not only is the ownership of the traffic facilities in diverse hands, but the control, as well as the regulation of them, is similarly diverse. It is necessary to consider the three types separately.

1. The Construction of Railways.

Railways are built almost universally under a private Act of Parliament, for only by this means can the privileges and powers enjoyed by a railway company be obtained. The procedure, through which a private bill has to pass before becoming an Act, enables all parties affected or interested to appear and oppose it before the committees constituted of members of each House of Parliament in turn, Lords and Commons. The grounds of opposition are very wide. Competition, the disturbance of property or other private rights, the seeking of conditions, limitations or restrictions as to the methods of working or conducting the business—always assumed to be in the public interest—and the policy pursued by public bodies under their enabling statutes as related to the project, are all good grounds. In the result a very considerable expense attaches to the promotion of a railway. In the result, again, many bargains are made in respect of the proposed railway which were not within the original intentions of the promoters, and many schemes are

put forward not because they are necessarily the best, but because they are most likely to successfully run the gauntlet of opposition.

The chief defect of the Main Line railway system of London is due to a policy which withheld all the Main Line railways from entering the central area. The chief defect of the underground system of local railways is the piecemeal manner in which they have been designed by small and separate companies and the lack of any powers of review left to the legislature, for the legislature may only accept, or reject, any particular bill presented to it. Amendments cannot go to the substance of the proposal. Following upon this dispersion of interests, there have been jealousies which are illustrated by distinct and adjoining stations at many traffic centres, representing double costs and involving only half as convenient interchange arrangements. And, as a last defect, the stations are often upon sites which are second best only, whereas the effectiveness of an underground and invisible system of railways is almost wholly dependent on evidence of it at the critical traffic point.

The possibility of an underground system of deep-level tube railways for London is due to the existence of a thick bed of clay, impervious to moisture, stretching underneath it. The turning to full account of this possibility for railway construction was rendered feasible by a provision of the legislature which fixed the compensation payable to the owners of the surface for the right to run tubes underneath, provided that the depth exceeded 40 feet below the surface. Under public streets or property, the price is fixed at a shilling per foot run. Under private property, the price is fixed at a sovereign per foot run. By other provisions of this period, protection is given against claims for damage and vibration arising out of the construction and working of the railway. It is under such special favourable provisions as these that London has been able to acquire the unique system of railways which now serves it.

2. The Construction of Tramways.

Tramways are built under Acts of Parliament in the same manner as railways. An alternative procedure, by way of provisional order, is available, where the initial enquiry is by officials of a government department (The Board of Trade), and is,

on this account, of less costly character. A provisional order is subsequently confirmed by Act of Parliament as a matter of form. With a view to simplifying the procedure for the obtainment of traffic facilities, the Light Railways and Tramways Act of 1896 was passed, which set up a body of commissioners for the purpose of enquiring into and adjudicating upon schemes submitted to them. The order of the commissioners becomes effective as soon as it is confirmed by the Board of Trade, and, not requiring the sanction of Parliament, curtails both the risk and the expense. Although the procedure to secure a grant of tramways is thus made less expensive and much easier, there are quite different difficulties in the way of a complete and homogeneous system. While in the County of London, the County Council is the sole authority entitled to construct and work tramways, and every private or other undertaker is excluded, the cities and municipal boroughs comprised within its limits have each a power of veto upon the construction of a tramway within their respective districts. Thus one can agree and one disagree, with the result of detachment of lines and the recasting and truncation of schemes to avoid prohibited areas. The door is also opened for negotiations on many questions, such as the type of construction, the services to be provided, the fares to be charged, the upkeep of the street occupied, and, particularly common and burdensome, street widenings and improvements. Not that this veto has not proved beneficial in keeping open large and important streets of peculiarly heavy traffic in the west of London, in checking a prodigal development of tramways of a little useful kind, and in preventing the occupation of unsuitable streets which frequently occur in old-built places. Outside the London County, both County Councils, Municipal Boroughs and Urban and Rural Districts are capable of becoming tramway authorities. Only where they waive their prior claim may the private undertaker come in, and in this case, purchase clauses, enabling the local authority to take over the tramways, are always included.

Another special type of opposition is that of the frontagers on a route. These are afforded an opportunity of exercising a veto under certain conditions and, always, of opposing individually.

As a consequence of vesting the power to build and work tramways in the numerous local authorities, tramways are under the control of many hands, just as railways, and not until quite recently, when the financial position of tramways was becoming precarious, have the local authorities concerted together to link up their systems and provide through services of cars and continuous schemes of fares.

Both railways and tramways are subject to provisions designed to secure the safety of the public and to limit the burden of charge which the public may be asked to bear.

3. The Licensing of Motor-Buses.

The motor-bus uses the ordinary streets of the cities and towns just as it finds them. It can ask for no privileged position, but must take its luck with any other competing form of traffic without protection. Therefore, there is no need or obligation on it to seek powers or rights from the Government, local or central. None the less, the central Government has seen fit to establish certain preliminary conditions with which a motor-bus must comply before it is allowed to work on the streets, and has given a discretion to the local authorities as to whether motor-buses shall be allowed to run within their district or not. These measures are rendered effective by requiring a motor-bus to take out an annual license. In London the complete effect of these measures is diminished by the fact that, in the Metropolitan Police Area, which corresponds closely with Greater London, the licensing authority for the whole is the Chief Commissioner of Police, and he is not vested with a discretionary power like the local authority, but must license the motor-bus as soon as the requisite conditions are duly met. These conditions govern the size, capacity and dimensions of the vehicle, the speed, the equipment and appearance of the body, and the efficiency of the engine. They are designed to secure that not less than a certain minimum of comfort is afforded whilst a maximum of safety is assured, and to prevent nuisance arising from noise, smell, or dirt. Incidentally, the granting of licenses is a source of revenue, for sums amounting to £5-18-0 per annum are payable in respect of each motor-bus licensed.

This, by no means, represents the total charge for taxation resting on the motor-buses. Outside the police area, the discre-

tionary power to grant licenses is being interpreted by the local authorities as a power to negotiate terms, though as yet only tentatively. There is increasing prospect of difficulties arising out of this, and already certain districts have refused licenses altogether, to the prejudice of their neighbours. To work the present scheme of routes in London, licenses have had to be taken up in 16 districts.

4. Inspection and Supervision.

When a railway or a tramway is completed and opened for traffic, the Board of Trade has a continuing oversight over certain aspects of its operations and business, chiefly with a view to seeing that the terms under which it came into existence are observed, but also with a view to establishing a high standard of safety, a uniform treatment of the public and a fair dealing with the staff employed. In the same way, the Commissioner of Police has a supervision over those aspects of the motor-bus industry which are governed by the conditions laid down for licensing, coupled, in his case, with the very effective power of suspending the license, and so removing the motor-bus from work, where he has reasons to be dissatisfied. But all this is rather incidental to the working of the traffic of London, than essential to the consideration of its problems. There is no power vested in any one to keep the whole traffic situation under review, or to treat of its real needs and conflicts.

IV. SOME CONSEQUENCES OF THE UNCOORDINATED CHARACTER OF TRAFFIC FACILITIES.

The consequences of the detachment and division of ownership, indicated in the preceding section, and the lack of coordination and control among the public authorities group themselves into three problems:

1. The isolation and lack of correlation between the urban and trunk railway systems.
2. The conflict between tramways and motor-buses.
3. The exposed position of motor-buses, and the conditions attaching to a franchise.

1. The Relations of Urban and Trunk Railway Systems.

The distribution of the Main Line termini on the borders of the central area has already been adverted to in this article. The

volume of traffic to and from these stations from and to stations within 30 miles of Charing Cross, the assumed centre point of London, is estimated at 365 millions of passengers in the year. Practically all these people have to rely upon other means of transit, such as urban railways, tramways or motor-buses, for the completion of their journey. As the inward and outward flow of this traffic is confined largely within a limited time, the problem of congestion grows acute, for the auxiliary modes of transit, with the exception of certain motor-buses, do not start at the main line termini with their services, but pass them on journeys from and to other districts of London where they have already obtained a load. In addition, the accommodation at the termini themselves for local services tends to press upon the accommodation for trunk services, and extensive and extravagant schemes of enlargement ensue. For, in addition to the high price of land in suitable sites, the enlargement of a station entails a widening of the approach roads over a considerable distance, which must either be in tunnel or on an elevated structure to avoid grade crossings in the streets.

An alternative method of dealing with this problem is the coupling up of the urban or underground railways, at some point beyond their zone of heavy traffic, with the main line railways, and the working of through services of trains within the limits of the flow of the suburban traffic of London. Towards this solution, various steps have been taken. For example, the Metropolitan Railway owns, jointly with the Great Central Railway, 22½ miles of line running out from Harrow, and terminating at a distance from London of about 40 miles. The District Railway owns extension lines to points such as Uxbridge, 20½ miles; Harrow, 14 miles; and Hounslow, 13¾ miles out of London, to which points it projects some of its principal services of trains. Then the District Railway runs over certain isolated sections of the London & South Western Railway to Richmond, 10 miles, and Wimbledon, 9 miles, and is jointly interested with the Midland Railway (Tilbury Section) in the running of trains to Barking, 9¾ miles out of London, and to Southend, 38 miles away. Most of these arrangements are of long standing and arose at a time when the distinction between urban and trunk railways was not drawn, and, in any case,

antedate the appearance of the tube railways. But the first real step in the direction of a modern solution on these lines was the agreement between the London Electric Railway and the London & North Western Railway, by which some two extra miles of tube railway were built for the purpose of linking the Baker Street & Waterloo Line up to the suburban tracks of the North Western Railway running out to Watford, a distance of 19 miles. This arrangement is coincident with the adoption of electric traction by this main line railway for its suburban traffic. The advantages of such an arrangement are many. The trunk railway comes into possession of a distribution system for its traffic, clear of a large central terminal; the urban railway acquires feeder connections into the territory outside London, waiting to be developed; the public gain almost invariably in more convenient journeys and reduced rates of fare. Now that the initial step has been taken, other railway companies are seriously considering it, and there is reason for strong hopes that the whole net-work of railways of all kinds serving London will soon be knit together into a coherent and easily used pattern. The disadvantages of such an arrangement should not be wholly overlooked. They arise from the restricted size of the rolling stock used in the underground tunnels. The standard diameter of the running tunnel is 11 feet 8 inches. The cars seat 48 passengers. The diameter of the wheels is 30 inches, so that the car floor is lower than that of standard main line coaches by 24 inches, and is out of relation to the heights of the main line station platforms. Only in the case of one urban line, was this factor brought into active consideration. This was in the case of the Great Northern & City Railway, a short length of line of 3½ miles, where the running tunnel was constructed to a diameter of 16 feet.

2. The Conflict of Tramways and Motor-Buses.

The second great problem is concerned with the conflict of tramways and motor-buses. This conflict has taken on a political character, which makes it more severe. The tramways either belong now, or will eventually belong, to the local authorities. Not any of the local authorities of London are empowered to work motor-buses, and the whole motor-bus industry is in the hands of privately owned companies. Both use the same streets,

and compete to some extent for the same traffic. The motor-bus has since 1912 proved to be a formidable competitor, and the financial condition of the tramways has become insecure. The traffic situation is illustrated in the following table:

L. C. C. Tramways.

	No. of Passengers	%	Avg. Rect. d.	Proportionate share of whole
1911	533,440,235		1.03	61.0
1912	512,652,653	3.9 (dec.)	1.02	51.0
1913	522,952,640	2.0 (dec.) on 1911	1.01	42.6

L. G. O. & Associated Motor-Buses.

	No. of Passengers	%	Avg. Rect. d.	Proportionate share of whole
1911	340,669,411		1.32	39.0
1912	492,858,934	44.7 (inc.)	1.32	49.0
1913	705,156,724	107. (inc.) on 1911	1.33	57.4

For the first half of the year 1914, the motor-buses carried 387,926,979 passengers, again a substantial increase on the preceding year.

A tramcar being confined to rails, and involving much capital expenditure for construction, is obliged to follow the main arteries of traffic.

The motor-bus, on the other hand, is free of every street which is capable of traffic. It can therefore develop in the areas adjoining the main roads. It can afford to pioneer in areas that cannot afford a tramcar. It is adapted to the affording of cross and interchange connections. Not running on fixed rails, the motor-bus adjusts itself easily to the conditions of traffic prevailing in a street. It does not create the blockade which congestion always induces in a tramway. It falls in with the moving stream on either side of the road and does not monopolize the centre. This is an important merit in the

central thoroughfares of a city. On the other hand, not running on rails, but using the ordinary surface of the road, it is subject to limitation as to weight. The total laden weight of a motor-bus must not exceed 6 tons. This weight limits the number of passengers that can be carried to 34. A motor-bus is, therefore, a small traffic unit, less adapted to the carriage of heavy peak loads than to the carriage of the constant pickup traffic of the streets. But experience shows that a quick succession of small units proves to be very efficient, and, added to the wide dispersal over many routes which is possible to motor-buses, this form of transit is capable of undertaking a vast deal of work, and of tackling a really heavy traffic density. To show the relative effectiveness of the two types of vehicle, the average load of a tramcar with 74 seats is 10½ passengers, and of a motor-bus with 34 seats is 8 passengers. The relative efficiency of the motor-bus, measured in percentage of seats occupied to seats offered, is therefore almost twice as great as that of the tramcar.

(Note. The distance the passenger is carried is not brought into this calculation, but as it must be almost equal for the two types of vehicle, the inference drawn from the figures is a correct one.)

The scheme of motor-bus routes worked in London does not contain a single instance where the motor-bus route merely parallels a tramway route. In every instance, the motor-bus gives a greater extension or a new connection to that given by the tramways with which it comes into contact. The tramway is laid out on a territorial basis, and the motor-bus, escaping from the artificial lines which form the boundaries of districts, is able to consider a route more purely from a traffic point of view.

The tramway, occupying a portion of roadway almost exclusively, is burdened with responsibilities in the way of repair and maintenance of the road surface so occupied. Again a tramway is treated as an owner of property, and is rateable on its profits, as on an assumed rental, towards local and public purposes. From both these burdens, the motor-bus is exempt. All it has to pay for its user of the streets are the license fees. Latterly there has been an outcry that the motor-buses were damaging the road surfaces, and this has been made the basis of

attempts, partially successful outside London, to specifically tax the motor-buses for the user of the roads. The central government has had to take account of this outcry, and is proposing to set up a special committee to enquire into all the aspects of the question.

Experience, so far, has shown that on roads with foundations made sufficiently strong to carry the weight of a motor-bus, and with a rigid surface such as that given by wood-blocks or the hardest asphaltic macadam, the wear occasioned by the motor-bus is less than the wear occasioned by other types of vehicle, and eminently less than that occasioned by horsed traffic. As a general principle, it might be laid down that, having regard to its importance to the life and health of a district, it were undesirable to put a tax on traffic facilities at all, but that rather everything should be done to secure them on as cheap a basis to the public as is possible.

3. The Exposed Position of the Motor-Bus Industry.

The third problem is not a pressing one at the moment, but it has arisen in an acute form in the past, and that is the existence of two or more powerful companies competing with each other for the motor-bus traffic. In the year 1908, there were three companies working omnibuses, both motor and horse, in London, whose relative size is shown in the following table. Only the motor-bus column counts as really effective, and in this class of vehicle all three were more or less equal.

	Horsed buses	Motor buses	Total
London General Omnibus Company	991	233	1224
London Road Car Company	222	195	417
Vanguard Company	—	242	242

In this year, 1908, the competition was so intense that all the companies were working at a loss. Services were duplicated, racing took place in the streets, and accidents were frequent. Just as the state of affairs was becoming a public question, an agreement for amalgamation was reached, and the London General Omnibus Company absorbed the other two. In 1911, the Great Eastern Company, which had been constituted in 1906, was also absorbed.

There is no existing means by which anyone wishing to

work an omnibus within the Metropolitan Police Area, or, in effect, Greater London, can be stopped from doing so, providing the vehicle he proposes to work with complies with the conditions and tests laid down by the police. Therefore, the amalgamation in the year 1908 did not close the door to a repetition of the evil situation.

The policy of a small owner differs fundamentally from that of a large proprietor. The small owner's costs are relatively larger, and he demands, therefore, a higher rate of earning to meet them. To obtain this, he requires to work his buses on a short central section of route where there is a preponderance of traffic and a greater profit. When several small owners adopt the same policy, the result is not good from a public point of view. On the other hand, the large proprietor is bound, in his own interests, to cover as wide an area as possible, to seek new openings and to establish himself securely in the task of meeting the public requirements. Since 1912, when the present management entered into control, the London General Omnibus Company has always had routes which were unremunerative.

From time to time, small fleets of motor-buses were placed on the streets, chiefly by manufacturers through operating companies formed under their control. In this way, some thousand motor vehicles had accumulated, about this year, 1912, owned and controlled by seven separate companies. With all the seven small companies, the London General Omnibus Company has entered into agreements by which it, in effect, pools earnings with them, and takes up the oversight of their traffic working. Only 18 motor-buses, owned by three companies of quite recent origin, are now outside this control at this date. The problem is, therefore, quiescent. Rumours of new motor-bus companies are frequent, and the fact that they seldom materialize is due to the growing strength of the associated companies in possession. The only real remedy would be the granting of a franchise to the existing companies, and then the problem resolves itself into one of terms.

A franchise means a monopoly, and where there is a monopoly it is reasonable to look for guarantees of the interests of the public. It would be reasonable to expect a limitation of

the amounts to be charged for fares, and in London, on the analogy of railways and tramways, special cheap facilities for workmen's traffic, a requirement of an adequate service, a progressive improvement in the vehicles and equipment and, lastly, some cooperation with the railways and tramways already occupying privileged positions.

Some of these matters are capable of expression at once in the clauses of an agreement, but others, and equally essential ones, are matters of judgment and experience. The crux of the problem is: Who is to be the final arbiter in matters of this sort,—is the company who may own the franchise, or the local authority who is the representative of the public?

The local authority is vested with the care of the public interests, and is entitled to see that the public transit service is adequately maintained to the most modern standard of requirements, at fares as low as may be remunerative. In the execution of these duties, the local authority may take a share in the provision of transit facilities, but, on this account, it must clearly put itself out of court as arbiter. It must on all counts occupy the position of prosecutor. The real problem, then, behind all the other problems, which arises from the multiplicity of interests and ownerships, the division of responsibility for the control and regulation, the lack of any system of review, is the establishment of an independent Traffic Board. This was the recommendation of the Royal Commission on London Traffic in 1907. Under this recommendation, it was to consist of a few expert members, and was to be armed with judicial powers of a wide and effective order. So far, only a statistical and recording section of the Board of Trade has been set up. Another alternative is more difficult. If the local authority were to divest itself of its power to interfere actively in the traffic of London, it might be given a judicial power in this matter, subject only to some guarantees to the companies incurring the financial responsibilities for the task, if the decisions of the local authorities proved to be inimical to the interests of those whose money was invested in the undertakings. Apart from the difficulty of undoing what is now done, there is a special difficulty in the number of local authorities concerned whose cooperation for success would be requisite.

Some solution of this problem is urgently needed; meanwhile the effort made by the Underground Electric Railways Company of London, Limited, to work out a solution independently is worthy of note. This company first acquired an interest in the District Railway in 1903. Subsequently it took over from the promoters the rights to build the three deep level tube railways, known as the London Electric Railway. This system was working complete in 1908. At this time it had also acquired control of a large tramway undertaking, the London United Tramways Company, Limited. In January, 1912, it took over the London General Omnibus Company, Limited, and has since then entered into agreements with practically all the other motor-bus companies working within the London area. In January, 1913, it extended its control over two other older deep-level tubes, the Central London and the City and South London Railways, and, as a last step, added to its interests two other large tramway undertakings. Today, it is responsible for the operation of 61½ route miles of electrically worked urban railway, 123 route miles of tramway and practically all the motor-buses of London. It has tended towards an ownership control, but, as such, it has no legal existence, no protection and, equally, no special obligations. This only can be said, that it has always regarded first the public interest, and its record for the years of its existence is unimpeachable testimony as to this.

V. THE VOLUME OF LONDON TRAFFIC IN 1913.

1. In Relation to the Traffic Facilities.

The total passenger traffic of London in the year 1913 is estimated at 2,372,539,027 passengers. This total is shared almost equally between the three types of traffic facility—the railway, the tramway and the motor-bus. The number of passengers carried on the local railways was 462,019,537, including under this head three sections of main line railways in London issuing separate annual reports and figures. This represents a traffic of 4,125,174 passengers for each mile of route and 1,966,041 passengers for each station provided. In the year 1907, a return was made by all the main line railways for the month of October showing the traffic which they carried into their terminal stations in London from points distant within thirty miles.

Based on these figures, the total number of passengers of a local character contributed by the main line railways is estimated at 365,190,972. This represents a traffic of 636,221 local passengers for each station provided. The total number of passengers carried by railways was 827,210,509, or 35 per cent of the grand total.

The number of passengers carried on the London County Council Tramways was 522,952,640. The number carried by the tramways, operated by other local authorities, was 124,285,454. The number carried by privately owned and operated tramways was 164,159,223. The total number of tramway passengers was 811,397,317, or 34 per cent of the grand total. This represents a traffic of 2,345,079 passengers for each mile of route, or a traffic of 291,870 passengers for each car provided. The number of passengers carried on motor-buses was 733,931,201, or 31 per cent of the grand total. In 1913 the traffic represented 211,082 passengers for each motor-bus provided.

2. In Relation to the Population.

If the total population of 8,471,146 is applied to the figure of 2,372,539,027 total passengers, the average number of journeys per head of the population works out at 280 per annum. So high a figure as this is only of recent occurrence. The year 1906, which marks the commencement of electric traction on railways and the development of the motor-bus industry, marks also a turning point in the volume of traffic. In this year, the journeys per head of the population were estimated at 164. The rate of increase over the eight intervening years is 70 per cent.

Further illustrations are available of the movement of traffic in London. For instance, at Golders Green station, the terminus of the Hampstead Line of the London Electric Railway, where the only means of direct access to the centre of London is by railway, the average number of journeys per head of the population is 260 per annum on this line alone. This is at a distance of just over 6 miles from Charing Cross. At the 1901 census, the population of this district was 22,450 persons. The railway reached it in 1907. At the 1911 census the population was 38,806 or an increase of 73 per cent, almost all due to the last four years. Then at Wimbledon, where there are two

railways, which form the only good means of reaching the centre, the journeys taken on one railway alone work out at 154 per head of the population served, or at something over 220 for both. This is at a distance of 9 miles from Charing Cross. Then again at Sutton, which lies at a distance of 12 miles from Charing Cross, and where, by reason of the distance, the railway is the only practicable means of transit, the railway journeys per head of the population to and from London are as high as 170 per annum. Lastly at Southend, 38 miles from Charing Cross and the nearest seaside resort to London, there is a regular flow of business traffic to and from London of over 4,000 people in a day, which works out at 43 journeys per head of the population served, per annum.

A converse illustration is the volume of the traffic moving in and out of the central area, the cities of London and Westminster. The available data on this aspect are confined to the passenger statistics of the local underground railways. Out of 426,420,444 passengers carried by them, 120,533,406, or 28 per cent, travelled to and from stations in the central area. If this proportion were to apply to other types of traffic facility, it would mean that over 664,000,000 people were carried into and out of this area. Such an estimate confirms a previous estimate of the wide difference between the day and night population of this central area, and emphasises the manner in which the unity of London is created by, and depends upon, the traffic facilities.

VI. FLUCTUATIONS IN THE VOLUME OF TRAFFIC.

The total traffic to be carried is not of so much importance to the various undertakings as is the incidence of the traffic throughout the months of the year, the days of the week, the hours of the day; an evenly distributed traffic being at once the most easily worked and most profitable.

1. The Course of the Year.

In considering the effect of the seasons on London traffic, it is necessary to sharply distinguish between the underground, or railway system and the surface, or tramway and motor-bus system, for the weather characteristics of each stand in contradistinction to each other. The seasons of fine warm weather

bring about a transfer of passengers from the protected railway services to the open motor-bus and tramway services, just as surely as the seasons of cold, wet weather bring about the opposite transfer. The effect of this transfer is to reduce the average winter railway traffic by an eighth. The increase on the surface systems, strengthened by the larger volume of traffic which genial weather induces, is a sixth more than their winter level. This is the most predominant feature in the shift of traffic during the year. The only other marked feature is the drop occasioned by the holiday season of August and September. The trend of traffic month by month follows some such course as this. January is a good month chiefly on account of pleasure traffic springing from the number of entertainments, pantomimes and plays, which crowd the Christmas festival and endure to about the close of the month, and from the after season sales of big drapery and general stores. February is a bad month, and for all the surface systems usually the worst of the year. March, April and May are the months during which the railways slowly weaken, and the surface systems slowly strengthen. These months are marked by public holidays at Easter and Whitsuntide when traffics are especially heavy. The close of May, the month of June and the beginning of July form the London season. June is the best traffic month of the year all round. July is less good, although the traffic is generally sustained up to the first Monday in August, which is another public holiday. At this point the summer vacation drop starts with great suddenness. Everyone goes out of town that can, and business and pleasure alike languish. August is the worst month of the year on the whole. On the railways, about a quarter of the traffic vanishes; on the surface systems, only a tenth. It is less marked on the surface systems because of the development of country pleasure riding that has taken place in the last two years. The poorer classes of the population, who cannot afford to go away for holidays out of town, take their brief holidays in rides out into the surrounding country. This drop continues well into September, and as the traffic comes back again it falls to the railways, for this month and October are the months in which the surface systems weaken and the railway system strengthens. It is a more quick transi-

tion. November is a variable month, contingent on the weather. December closes the year with a good month, due to the extensive shopping and other preparations for Christmas.

2. The Course of the Week.

There is nothing sensational in the course of the traffic throughout the year, and the same may be said of the course of the traffic throughout the week. Setting aside days of extraordinarily inclement weather and days of extraordinarily heavy traffic, like the annual shows and feast days, the characteristics of the week are constant. Sunday has the least traffic of any day; on the railways only half and on the motor-buses some four-fifths of that of an average weekday. Monday to Friday present little change. Wednesday and Thursday excel the other days, because the mid-week shopkeepers' half holiday of the suburbs falls on one or other of these days, and mid-week distractions seem to come to vary the regular round of domesticities. Superstition militates against Friday's traffic. Saturday is the day of largest traffic, exceeding the average day by a tenth on the railways and a sixth on the motor-buses. This is by reason of the addition of the pleasure traffic of a general half-holiday to the normal business traffic. The relative gains of motor-bus and railway indicate how much the surface systems enjoy the greater share of the pleasure riding. Throughout the week, the variation in the traffic is fractional.

A note may be added upon one satisfactory aspect of the Sunday traffic of the railways. It has been increased at a much faster rate than the weekday traffic. On the District Railway, largely as the result of advertisement, the Sunday increase over the last five years has been 25 per cent, as compared with an increase of 11 per cent on weekdays.

3. The Course of the Day.

It is when the course of the day is considered that the variations become of substance and concern. At this stage, the railways have to be taken separately as showing the widest divergence. Data of this sort are not available for the tramways, but it is presumed that their characteristics are similar to those of the railways. On the motor-buses, the divergence is never very great. A diagram illustrates the contrast. (A).

On the railways and tramways, the peak load of the morning is accentuated because of a class privilege which is deeply embedded in the traffic arrangements of London, and is consecrated by statutory enactment. This is the cheap workmen's return fare, which almost corresponds to the single journey fare at other times of the day. The outward journey must be commenced before 8 a. m. as a rule, but the return journey may

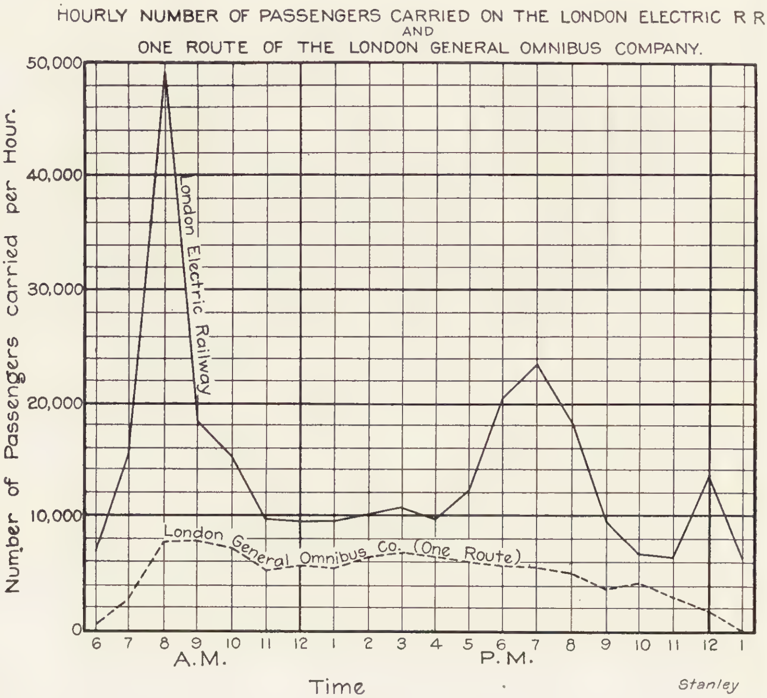

Diagram A.

be at any time of the day after noon. The wider limits of the return journey cause a better distribution of the traffic in the evening between 5 o'clock and 8 o'clock. The morning rush to business and the evening rush home have their slender counterparts in the evening rush to pleasure and the night time rush home. The evening rush to pleasure is covered by the evening rush from business, but the night time rush home, from 11 o'clock to 12 o'clock midnight, is clearly visible on the diagram.

The motor-bus, when operating in conjunction with other means of transit, has not a peak load. One reason is the absence of the workmen's return fare, which cuts it off from a fair share in the traffic before 8 o'clock in the morning. Another reason is the smallness of the units required to be filled with traffic, which allows of a closer adjustment to demands. A further reason is the special feature of motor-bus traffic, in that it consists of traffic casually picked up all day long, so long as there is traffic in the streets. The motor-buses are always reasonably full throughout the day. At the time of peak load they are quite full. They cannot overcrowd like railways and tramways, for the terms of their license from the police forbid it. Today, on account of the withdrawal of buses for the War, they are specially allowed to stand five passengers inside as a temporary measure of relief.

It is in the variations of the day that the operating problem of accommodation arises, where the ratio runs from one to five. Yet for all this, it is not an acute problem in London. The worst point for overcrowding on the railway system is at Whitechapel in the east end, and is almost wholly due to the peculiar workmen's privilege. A chart (B) shows how bad this is, and, by way of comparison, another chart (C) for the west end of the same railway, for the corresponding point of maximum traffic on that side, shows how good it is.

Much effort and many improvements have gone towards the securing of this result, and the problem has been kept within manageable proportions.

VII. IMPROVEMENTS IN RAILWAY CAPACITY.

1. Electric Traction and Automatic Signalling.

The District Railway, commencing as a shallow steam railway and being converted to electric traction in 1905, first of any railway in London, has the longest and most interesting record of improvements and progress. The main section of this railway, over which all trains serving the central area must pass, extends from Mansion House Station on the east, to west of Sloane Square Station on the west, a distance of four miles. It consists of two tracks, one for each direction. At points eastward of Mansion House Station, which has terminal facilities,

it diverges into three separate branches, and, at points westward of Sloane Square Station, it diverges into six. From and to each of the six westward branches, services of trains run through on to the main section. With trains converging at so many points, the problem of timing the trains in, to give a uniform interval at as many points as possible, is difficult in the first place; but even more difficult is the problem, which arises fresh with every day's working, of bringing the trains to the

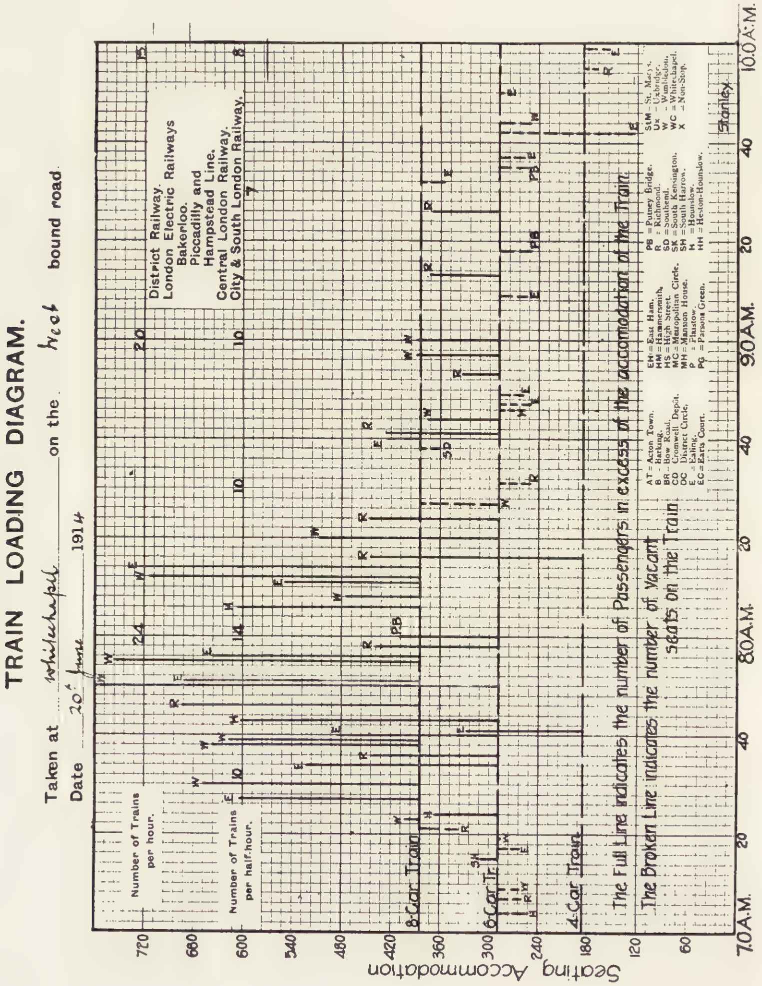

Diagram B.

converging points at the correct moments amid all the little unevennesses and mischances which will occur whatever care is exercised.

Under steam conditions, the best result was a succession of 18 trains in the hour in each direction over this main section. Under electric conditions, but chiefly due to the substitution of a system of automatic signals giving shorter block sections for

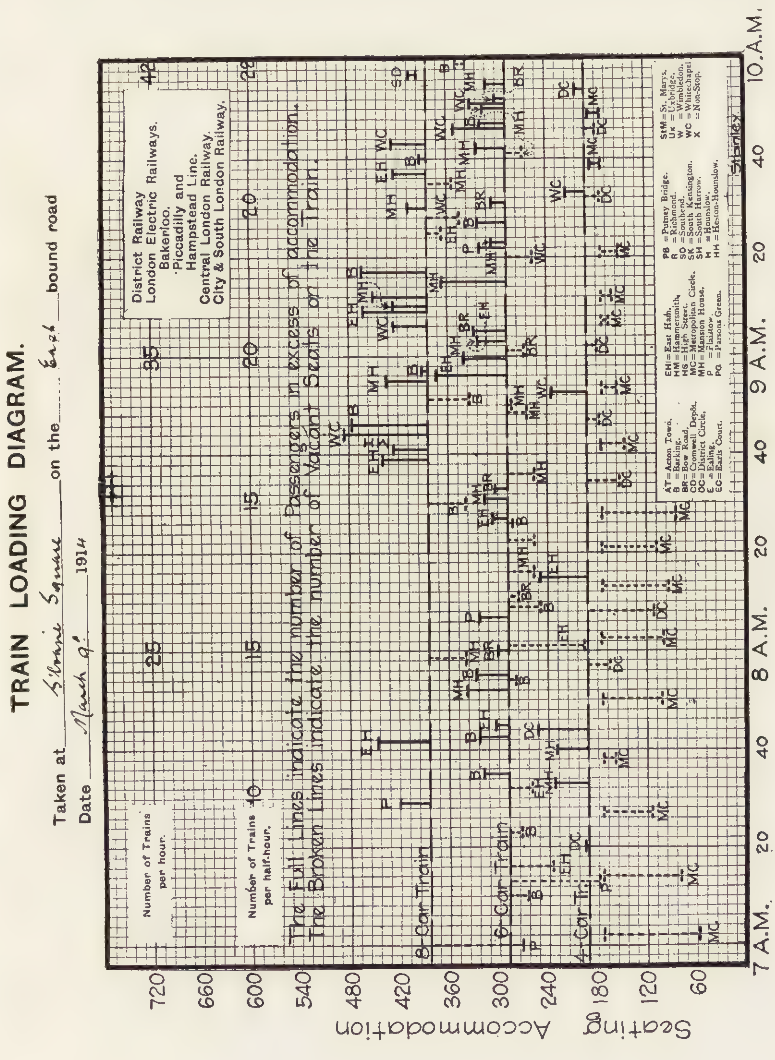

Diagram C.

the old manual signals, the number of trains in the hour each way was raised to 25, varying from 24 to 27 with successive time-tables in 1906-7.

In 1907, the need was felt for some increase in the service provided, if the development of the traffic was to be encouraged. The change in motive power had not so far produced a corresponding change in the alertness and dispatch of the train and station staff. Experiments were made in the way of starting the trains from stations and in the way of securing a quicker rate of unloading and loading, and at the close of 1907 the number of trains reached 31 in the hour.

The year 1908 brought a reconsideration of all the branch services which went to piece together the total service on the main section, and, by a rearrangement of these services to avoid possible clashing and delays, the trains crept up to 35 in the hour. During this period, the platforms throughout the line were reconstructed and lengthened to take eight cars as a maximum train length, and, in the then physical state of the property, it was not practicable to carry the frequency to any higher pitch.

2. The Elimination of Flat Junctions.

About the year 1910, a series of works was commenced, having for its object the amelioration of the property and the raising of the standard of operation to that of the latest constructed railways. The first work was the redesigning of the Mansion House Station. This station consisted of two through tracks placed between two island platforms on the outside of which were two terminal tracks. To use a terminal track, involved, either in entering or leaving, the blocking of the through tracks in both directions. As redesigned, it consists of a terminal track between the two through tracks, with a relief siding on the outside used for storage only, and by this means the blocking of both tracks is avoided in ordinary train working.

Concurrently with this alteration, and proceeding during the succeeding year, steps were taken to overlap the block sections throughout the main line so that the distance between trains approaching stations was reduced to the minimum space required to ensure safety under the given working conditions.

In November, 1911, the number of trains in the hour was 37 in each direction.

But the chief obstacle to progress was the existence of so many junctions on the flat where trains, crossing over from the branch to the main line, blocked the tracks in both directions. The policy of transforming the flat junctions into flying junctions, where, by differences of level, the tracks for one direction are carried over or under the tracks for the other direction, dates from the year 1910. In this year, the junctions at Acton Town, an outlying point, were completed. In 1911, the junctions for the Richmond Line were similarly treated and coupled with a doubling of the line to four tracks over a short length. The benefit of this was felt in the increase of the main line trains from 37 to 40 in the hour. In 1914, the junctions at Earl's Court were similarly treated and again coupled with a short doubling of the line, and benefit again accrued in the increase of the trains from 40 to 43, at which figure it now stands.

When all the schemes for improvements in contemplation are executed, it is expected to approach to a capacity of 50 trains in the hour in each direction as a maximum.

Only on one other railway in London is there a service at so high a level, and that is on the Hampstead Line of the London Electric Railway, where the frequency is 44 trains in the hour at the busiest times. At practically every point on the urban railway system, it is possible to afford traffic facilities adequate to the volume of traffic requiring to be carried. This does not mean that there is no overcrowding, for overcrowding, in the sense of people standing in the cars, must be regarded as a permanent feature of the rush periods of urban traffic operation. But the overcrowding, under all normal or expected circumstances, is not such as to result in discomfort or undue congestion.

3. The Problem of Peak Loads.

The reason why the problem of peak loads is not acute in London, as in so many cities, is two-fold. In the first place, the development of London has taken place with considerable uniformity in all directions, and, while there is a greater development and a greater traffic on the east and west axis, it is not totally disproportionate to the development and traffic of the

north and south axis. The passengers that come into the central area come in from all sides, and are distributed over many lines of approach, so that the volume to be handled on one line of approach does not present the difficulty which a restriction in possible lines of movement would create. In the second place, there is some public advantage in the duplication of the means of transit, which is so common a feature of London, so that on a given line of approach there are always two possible alternatives of railway, tramway or motor-bus, and in many cases, all three.

In this connection, the adaptability of the motor-bus to a wide distribution of a stream of traffic is not to be overlooked. For example, the stream of vehicles passing through the principal street between Oxford Circus and Bond Street consists of 14 different routes, which fan out on either side, and afford connections to quite a number of suburbs direct, in a way in which a tramway or a railway involving expensive initial construction could not afford to do. On the tramways, the peak load problem has been met by the addition of trailer cars. The use of trailer cars is open to argument in London on the grounds both of safety and efficiency, and the practice cannot be considered as finally settled.

Looking ahead, there is no reason to anticipate that density of traffic will ever become a critical factor in determining a policy for the development of traffic facilities in London. The determining factor is not likely to become the mere movement of quantities of passengers, to the sacrifice of other factors.

VIII. THE TRAFFIC CLASSIFIED AND DISTRIBUTED ACCORDING TO THE RATE OF CHARGE.

The acute problem of London is the problem of the fare. Some attempt has been made to describe the piece-meal and disconnected way in which the traffic facilities of today have been brought into existence, and with nearly each one adventures in fares have been associated. There is a historical background to London traffic, and, interesting as history is, it enshrines, in the present, relics of the past which stand tenaciously in the way of a harmonious and coherent system. There is no "fares system" in London. The traffic may be analysed into

three principal classes and over many rates of fare, but there is no clear definition about any of the figures in relation to the fares charged.

1. On the Motor-Buses.

The motor-buses have only one price for a journey, that of the ordinary single fare, varying according to the length of the journey. A few transfer tickets, limited to a definite exchange point, where a short connecting service is run specially to link together two important groups of routes, serve in their scantiness to enforce the general principle of a payment on every motor-bus for the ride taken. A few cheap return tickets, copied from the tramways, are again too insignificant to count. Over 99 per cent of the traffic is carried on a straight ordinary fare.

The distribution of this traffic over the different rates of fare shows that 12 per cent paid a halfpenny and 57 per cent a penny, so that 69 per cent, or over two-thirds of the total, is short distance traffic.

Above this price, 9 per cent paid three-halfpence; 13 per cent, two-pence; 3 per cent, two-pence-halfpenny; 3 per cent, three-pence; and 3 per cent, more than three-pence. The average receipt from the whole of the traffic is 1.33d per passenger.

2. On the Tramways.

On the tramways, there are two distinct classes of passengers. There is the workmen's traffic, travelling on cheap return tickets at fares equivalent to about half the ordinary fare, in pursuance of a statutory privilege to which reference has already been made; and there is the ordinary traffic corresponding to that of the motor-buses. The workmen's traffic is almost 10 per cent of the whole on the London County Council system. Latterly, an extensive experiment has been carried out in the way of cheaper return tickets for ordinary passengers, but so far no results have been published to show whether this has been successful. At the same time, transfer tickets have been introduced, but again with no publication of results as to use or abuse. These experiments arise out of an attempt to counteract the effect of the motor-bus competition on the tramways traffic.

The distribution of the traffic on the London County Coun-

cil tramways, workmen and ordinary together, shows that 32 per cent paid a halfpenny and 46 per cent, a penny; or that 78 per cent is in the category of short distance traffic, a somewhat larger proportion than that of the motor-bus traffic and, due to the inclusion of longer distance traffic, travelling under the cheap rates for workmen. Above this price, 7 per cent paid three-halfpence; 8 per cent, two-pence; 1 per cent, two-pence-halfpenny; 4 per cent, three-pence; and 2 per cent, over three-pence. The average receipt from the whole of the traffic was 1.01d, and for the ordinary traffic, exclusive of workmen, 1.12d.

3. On the Railways.

On the railways, there are three distinct classes of passengers. There is a statutory workmen's traffic, as on the tramways. There is a large commuted traffic travelling on season tickets, calculated at 10 or 11 fares for a week's riding, and issued for one or three months as a usual period. There is no limitation in the number of rides which may be taken on a season ticket, and, from observations made on urban railways, the number approaches an average of three per day, so that the discount on this class of passenger is quite appreciable. Lastly, there is the ordinary traffic.

Taking the London Electric and Metropolitan District Railways as typical of the urban system, then 16 per cent of the total traffic falls into the workmen's class and 8 per cent falls into the commuted class, leaving 76 per cent of ordinary passengers. On some railways there is a further class distinction into first and third, but this is of little significance and may be ignored. The first class traffic is some 4 per cent of the total ordinary traffic.

It is possible to give figures for the London Electric Railway, distributing the ordinary traffic over the different rates of fare. There are no halfpenny fares on the railways; the penny traffic is 25 per cent of the whole, contrasting strongly with the proportion on the surface systems. Above this, 9 per cent paid three-halfpence; 32 per cent, two-pence; 5 per cent, two-pence-halfpenny; 23 per cent, three-pence; and 6 per cent over three-pence. The average receipt from the whole traffic of this railway is 1.68d, and for the rest of the traffic,

excluding the workmen, 1.86d. The inference to be drawn from the figures is that the railway, as would be expected from its superior speed, meets the requirements of the long distance passenger.

IX. THE FARES CHARGED.

The key to the fares situation of London is the rate of charge for ordinary passengers, as the fares charged to workmen and other favoured classes are based finally upon the fare for the ordinary passenger.

1. Factors Affecting the Amount of the Ordinary Fares.

There is no one person who can fix the ordinary fares of London as he likes, so many people are interested in them, and so many factors, almost as many as there are people, come in to govern the possible development of a uniform situation. Some of these factors may be indicated here. In the first place, railways and tramways have certain fares fixed for them by statutory enactment. In the second place, there are the anomalies surviving from the past and confirmed, in a conservative mind, by daily use and wont so as to be almost past disturbance. There are numbers of agreements made in early days affecting small points in fares in an incidental manner which have a wider effectiveness in these later days than was originally contemplated. In the third place, there is the continued conflict of interests in London traffic which led in the past, and may again lead in the future, to fare cutting, not, may be, universally, but only partially and locally. Latterly the policy of the London County Council, as the tramway authority, has been towards reductions of fare over all its system, and this policy raises a curious question having regard to the financial condition of its tramways. These tramways are not necessarily worked under ordinary commercial conditions, as there is behind them a financial guarantee out of which to meet the losses, by an addition to the public rates. The payment of rates falls on fewer shoulders than the payment of fares, and there must be a constant temptation towards a cheapening of the cost of travel. This temptation is the more insidious because it is a patent fact that, up to a point, the cheaper the fare, the greater the volume of traffic and the better the general result. This has been the

experience obtained in the whole series of fare reductions, but only up to a point. There is a saturation point for traffic, and to over-pass this point with further reductions, is only to suffer loss; but against the risk of this, there is in existence no guarantee. Lastly, there are the efforts of different experts to so adjust the fares as to charge what the traffic will bear under the particular theories which they may chance to hold.

2. Coinage in Relation to Fares.

One factor affecting the amount of a fare is deserving of more detailed consideration, because it has a positive determining effect, and that is the coinage of the country. It is necessary to take note of what are the common coins of the country, and the relation existing between the several denominations of coins. In London, the common coins are the penny, the halfpenny and the farthing. The numbers of these coins in circulation at the close of the year 1911 were:

Pence	836,950,560
Halfpence	507,821,280
Farthings	211,060,800

The figures are given to show that the halfpence and farthings must still be counted as effective coins. The farthing has no relation today to charges for passenger traffic, and so it may be ignored; but the halfpenny has, and calls for attention. There are not two pennies in circulation to each halfpenny. The halfpenny press has an enormously greater circulation and popularity than the penny press. The halfpenny cannot be ignored. These are bronze coins. The lowest denomination of silver coin is the threepenny bit, and the next highest, the sixpence. Of threepenny bits, there were issued in the last ten years, 54,000,000, and of sixpences, 80,000,000. The threepenny bit is not to be regarded as a convenient coin, owing to its small size. It has a lucky significance, and certainly tends to be easily lost. On the other hand, the sixpence is a coin too highly valued to be of much use in connection with a scheme of charges for urban traffic, so that this pertinent factor has to do solely with pennies and halfpennies.

3. Costs of Operation per Passenger.

While it cannot be regarded as a factor determining the amount of the fares, yet the amount of the fares must have

some relation to the cost of operation per passenger. For the year 1913, the results of operation of several of the companies working in London may be set out in tabular form to illustrate this point:

	Gross earnings per passenger d.	Expenses per passenger d.	Net earnings per passenger d.
London Electric Railway	1.68	.83	.85
Central London Railway	1.60	.94	.66
City & South London Railway	1.54	.97	.57
District Railway	1.83	.88	.95
London General Omnibus Co., Ltd.	1.33	.94	.39
London County Council Tramways	1.01	.73	.28

While not any one of these figures can be looked upon as a stable indication of the level of cost, the sequence of them may be taken to tentatively point to the fact that for the railways, at any rate, the cost of operation swallows so much of the penny as to make an average receipt of this sum inadequate for the payment of a reasonable rate of interest on the capital invested in them, and that while, for the tramways and motor-buses, an average receipt of approximately a penny enables them to fairly discharge all their obligations, it leaves no margin of security against mischance or ill-luck, nor any margin for the future development of the system, which is a matter of urgent importance. On the whole, it is necessary that the average receipt from passenger traffic in London should exceed a penny, and that on the railways, with the growth of the Metropolis and the increase in longer distance travel, it should approach more closely to twopence than it now does. The levels of average fare for the two opposed systems, the underground and the surface, are disparate, and this adds another complexity to any consideration of the fares problem.

4. The Existing Scale of Fares.

Sufficient data have been given to show that, once and for all, London is prevented from adopting a flat fares scheme similar to that which obtains in most cities of America. The flat fare, to please, would have to be a penny, for almost 70 per cent of all the existing traffic is carried at or below this price, and the penny is not practicable traffic politics.

A flat fares scheme has been tried in London on the Central London Railway. From the date of its opening until 1906, it persevered with a uniform charge of twopence. In this year, it carried 36,722,497 passengers, of which 11.65 per cent, or 4,278,171, were carried over short distances up to three stations and 24.21 per cent, or 8,890,516, were carried over long distances exceeding 9 stations. From 1906 onwards, this railway has felt particularly the competition of other railways and of motor-buses, and has had a constantly declining traffic. At first it had given up its original single fare of 2d in favour of two fares, 2d and 3d, and, in 1913, had gone further still with the introduction of a penny fare. In this year, the penny passengers numbered 15,459,827, which, compared with the 4,278,171 of 1906, shows an over three-fold growth. The threepenny passengers numbered 2,907,795, which, compared with the 8,890,516 of 1906, shows an exactly inverse decline. Here again, the large influx of penny passengers shows the public demand for a ride at the price. So that, failing a penny flat fare, a differential scheme of fares is inevitable, and this is the scheme which London has.

The differential scheme of fares adopted in London has relation to distance as its criterion. There are critics of this, in that distance has a varying value in different quarters of the Metropolis. For instance, on the short north and south axis the fares tend to be higher than on the long east and west axis, because there is a feeling that the two should correspond in price for what are really equivalent services. Again, in the prosperous west-end, as opposed to the working class east-end, the rate of fare per mile tends to be higher, though this is more a converse illustration of a variation in the value of money. Other criteria might be suggested as a basis for a differential scheme, such as the value of the service rendered, the time at which the journey is to be performed, a geographical arrangement of zones; but all these are foreign to the existing practice of fare making, and at enmity with existing fares.

In order to illustrate the scale of fares which is now in force, the London Electric Railway may be taken as representative of the railway system, and the London General Omnibus Company as representative of the surface system. Taking the

fares of these companies, and averaging the distances offered for each separate fare at each denomination, it is possible to make a comparison of the relative distances carried by each of them for a given price. This is shewn in the following table:

Rate of Fare	L. E. R. Miles	L. G. O. Co., Ltd. Miles	Difference Miles
1d	1.4	1.7	.3
1.5d	1.9	2.4	.5
2d	3.2	3.4	.2
2.5d	3.9	4.3	.4
3d	5.1	5.2	.1

The result is that not only is there a differential scheme of fares in London, but two such different schemes, the one for the railways and the other for the surface systems. The discrepancy between the two schemes is less marked in average figures than in actual direct comparisons, for an average always tends to hide the extremes; though for the purpose of this comparison it is a fairer figure.

The discrepancy between the two schemes is greatest at the lowest fares, and tends to become less as the fare increases, until at over 3d, the railway is as cheap and often cheaper than any other means. This arises from the railway practice of adopting an accumulative or sliding scale of charges, in contrast to the older practice of the motor-bus and tramway of arriving at the higher fares by a simple addition of the lower ones. In imitation of the railways, the surface systems have copied the sliding or accumulative scale in part, and are tending to copy it extensively. As their base distance at one penny is greater than on the railways, the extension of their higher fares tends to a very great degree of cheapness, so that fares get to be at rates much under even a halfpenny a mile.

X. THE FARES PROBLEM.

1. The Equalization of Fares.

It will be recognised how exceedingly intricate and complex is the fares problem that awaits solution in London, and how full of pitfalls are the paths open to the reformer. This very complex situation is an explanation of one great source of struggle for London traffic. There is no rest and no finality

in any dealing with fares, and month by month changes take place in the way of closing up the gaps on one side, and, again, of widening the gaps on the other side. There is no standard or definition of what is a reasonable or proper fare to which the many people taking part in the game can refer. The statutory level is a penny a mile, but this is in excess of what is a practicable level. It may be generally stated that the railway fares are, if anything, on the high side, and for several years now, as opportunity offered, a succession of steps have been taken by way of bringing them down to a better level. These steps have not enabled them to overtake the level of the surface fares, and there are still many steps to take, but the whole tendency is towards an equalization of fares, at any rate at the lower prices. There seems little reason why, up to 3d, the rate of charge for all systems of transit should not be approximately alike. Over 3d, the advantage in rate of fare might reasonably rest with the railways, as they, only, are in the position to meet the requirements of the long distance traffic. Meanwhile, the multitude of discrepancies continues, and some fares have fallen below a remunerative level. Sir Thomas Gresham in the Elizabethan time made the discovery that spurious money always tended to oust good money from circulation, and a similar effect may be traced among fares. A low fare, or, rather, a bad low fare, always tends to eat into all the other fares in its neighbourhood, and for this there is no cure. This is the great pity of the mistakes. The downward path is the easy path, but to put a fare up calls for much courage and obstinacy. It is a very rare occurrence that a fare is put up.

2. Excessive Differentiation.

The differentiation in fare is also carried too far. The jump in price from 1d to 2d is 100 per cent, and the 1½d stage is useful in breaking this down. The jump in fare from 2d to 3d is 50 per cent, and the 2½d stage may also be useful as a bridge here. People have a tendency to save their halfpence, even by getting out at a point short of their real destination to save passing into another fare stage, and at a penny rise this tendency is accentuated. The jump from 3d to 4d is only 33 1-3 per cent, and at this point the full penny rise is only proportionately equivalent to the previous halfpenny rise, and the ½d

stage does not seem to be warranted. A fares scale is thus possible with the following denominations: 1d, 1½d, 2d, 2½d, 3d, 4d, 5d, 6d. Beyond 6d, there is scarcely need to go, for all regular traffic. In fact, 4d seems to be the limit fare. Regular traffic from beyond the 4d limit is almost wholly commuted traffic, and then goes no further than the point at which the commutation works out to an extended 4d limit.

The application of these denominations is further complicated by the problem of the choice of the accumulative or the simple additional scale to which reference has already been made. The accumulative scale has a real value in affording ever widening zones round the point from which the reckoning is taken, for every increase in price. It affords much greater scope for development, without insisting upon a low initial basis. It must be regarded as a fixed element in any London scheme. It has the defect of obscuring the basis of charge, so that there is no sure and easy way of advertising to the public what the fare is between any two stage points or stations. It is easy to add fares together, but difficult to adjust them in accordance with some progressive scheme of discounts.

3. The Characteristics of a Fares System.

This point brings up the question of what are the characteristics of a good system of fares. That they should be even in their incidence, sure and settled in their composition, known in their existence and simple in their arrangement, seem the four cardinal qualities. None of these qualities are present in the London scheme as it is today, and there is the great drawback and the great puzzle—a new fares system for London, which will give the public what they want, which is as much for their money as they can get; and give the traffic companies what they want, which is as much business as they can carry; and give the shareholders what they want, which is a fair and steady dividend.

XI. THE FINANCIAL RESULTS OF 1913 AND THE PROSPECTS FOR THE FUTURE.

1. The Heavy Capitalization and the Low Return.

A vast deal of money has been sunk in the provision of the traffic facilities of London, amounting to over £90,000,000, with-

out bringing into account the expenditure of the main line railways within the area, for this cannot be ascertained. Of this amount, £66,000,000 is in the position of ordinary capital sharing the net sums earned, whether they be great or small, and the unfortunate fact remains that they are small—too small to place this great enterprise on a prosperous or satisfactory footing. The total amount available for dividends on the ordinary capital was in 1913, £1,390,000, or only sufficient to pay a dividend of just over 2 per cent all round.

Of the amount spent, £63,000,000 represents the urban railways. The largeness of this figure is due to the high cost of construction per mile of the original deep-level tube railways. The London Electric Railway has cost £785,000 per mile of railway open for traffic.

Certain sections of the District and Metropolitan Railways, in the central area, have cost as much as £1,000,000 per mile. This is a terrible sum to pay a dividend on out of penny fares.

The only real remedy for this is expansion of traffic.

2. Expansion of Traffic.

Large as the traffic in London is, it is not so great as that of other great cities of the world, proportionately to its size. Greater New York, for example, has a population which travels 338 times in the year per head, and there are several other big American cities approaching the 300 line. In Europe, Greater Berlin has a population that travels 293 times. It may confidently be expected that London will increase its journeys per head from 280 up to 300 in the next few years, and it is a piece of arithmetic what this means to the existing companies. To pay 4 per cent on the capital now invested, that is, to realise a net earning of £1,390,000 more after allowing for increase in expenses, requires an extra 36 journeys per head of population at the present average receipt per passenger.

But the population is not stationary, and so, with increased facilities, a hopeful conclusion may be looked for. There are two limits set to the traffic expansion, the limit of fare and the limit of time occupied on the journey. London is not yet developed to the area of fare limit or of time limit, so that there is ample room for growth. The fare limit has been indicated at 4d; the time limit may be set at 40 minutes. The time zone is

capable of greater extension by the adoption of various operating expedients, such as faster train equipments, non-stopping and through express connections.

3. Advertising for Traffic.

People need to know what the traffic facilities are if they are to use them freely. Ordinary people will only take the trouble to learn on their own account the way to and from business or the places of their regular resort. If they are to learn much else, they have to be told over and over again in different ways until it is stored in their memories. This is the aim and purpose of advertisement.

It has been the policy of the Underground Electric Railway Company of London, Limited, to make a liberal use of the arts of advertisement in connection with its many traffic undertakings. To this end, millions of maps of the Underground system have been printed and distributed, and maps of a more permanent character in glass or enamelled iron have been fixed where they can always be seen. Direction signs and notices with a specific device have been placed at important street corners, at sports grounds, at amusement centres, at main line stations and everywhere where people congregate, in so far as permission was obtainable on reasonable terms.

Picture posters and leaflets are issued month by month, of current interest, and containing such novel elements as have come to hand. Notices are placed in the newspapers, and, generally, an extensive campaign in the way of dissemination of news and information is always being carried on. To this campaign is to be attributed part of the growth in London traffic, and from it more growth is to be anticipated in the future. It has also served to establish in the public mind a feeling of goodwill, which is not one of the least assets. It is common opinion in London that the advertising of this group of companies is of remarkable and noteworthy interest. It may therefore be said to have fulfilled its aim and purpose.

4. Conclusion.

But unless to the detailed solution of the commercial and operating problems of the movement of traffic there can be brought a spirit of coordination and cooperation, the solution can never be complete or conclusive. Only in this way can the

development of the traffic facilities be carried out with economy, and the traffic conserved to afford opportunities for dividend on the money already sunk in their provision.

DISCUSSION

Mr. Owens. **Mr. James M. Owens,*** Assoc. M. Am. Soc. C. E., referring to the paper on London Traffic, compared the chapter "On the Conflict of Tramways and Motor-Busses" to the case in San Francisco, pointing out that the motor car would become a serious competitor to the municipal surface cars if it were not heavily licensed. In London the financial condition of the tramways had become insecure, due to the encroachment of the motor bus.

Prof. Cory. **Prof. C. L. Cory,†** Fel. A. I. E. E., noted that traffic systems have not usually included the element of graduated service. Cleveland has such a service. The fares for urban travel vary from 3 to 5 cents, depending upon the distance, and the fare for the suburban residence district is 10 cents. All charges are made on the general basis of distance traveled; thus, people living in the outlying districts must accept penalization by adding to their cost of transportation.

The advent of trackless transportation will limit the development of the outlying districts. It cannot be expected that any system will give a uniform fare for short urban hauls as well as hauls to the outlying districts. This will naturally tend to diminish the value of suburban property, and have a tendency to fill up the apartment houses. While this is to be deplored, it has, however, happened in Cleveland. People who find their work in the city must also live in the city.

Referring to elevated roads, he noted that while Philadelphia is a conservative city, yet it has adopted the elevated railway. The type is much better than that in New York and Chicago.

For the steam roads the problem is much simpler. They have an absolutely private right of way and deliver people to one central point. Thus, by using the steam road, people gain in time over the surface lines, and they are willing to pay for the difference.

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Paper No. 52

TRANSIT PROBLEMS IN AMERICAN CITIES.

By

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HISTORY AND DEVELOPMENT OF TRANSIT FACILITIES.

New York City.

On Manhattan Island in the early part of the 19th century, limiting the area to places about 5 or 10 miles from a given centre, any idea in the minds of the public as to celerity in traveling was apparently very limited, and economy in the saving of time was a virtue not yet acquired by the people of those days, particularly those who were compelled to ride and were actively engaged in the pursuit of business, having to go regularly from their homes to business. If a person really did want to "hurry" for a considerable distance, the rapidity of his movements was entirely dependent upon how much speed he could acquire by means of the "old horse", for in that period the horse-drawn vehicles were looked upon as the most modern means of locomotion and were the only means of transit. It was in the year 1801 that the first public horse-drawn vehicle was run wholly within New York City to accommodate paid passenger travel, and the crudest kind of method and animal propulsion was used to carry the public—then numbering on Manhattan about 60,000 people—over a limited area, traveling leisurely around. As a review in the history of transit conditions appertaining to New York City, and reaching other cities mentioned in this paper, we might hark back to June 25th, 1772—the population in New York City at that time being only 30,000 people—when the first stage coach line was established between New York City and Boston (as authority for this statement I refer to an advertisement published in a New York

paper of the above date); and some years later, about 1785, a stage line was run between New York City and Albany and Philadelphia. The trip to Boston took six days, sometimes longer, and about three days to Albany or Philadelphia, with coaches pulled by four horses, traveling in the day time from 3 A. M. until 10 P. M.; a journey that must have jolted the bones of the passengers, given them much exercise and severely taxed their patience—but, according to history, full of thrills and adventure—with surely no incentive to repeat the journey and further traveling, but, it would seem, being rather an inducement to stay home.

Referring again to the above-mentioned advertisement, as a real object lesson to the transit managers of to-day, showing how the passengers of those early days in the above-mentioned cities were coaxed to travel, the interests of the traveling public (?) were best conserved, and one traffic problem solved, a copy of the advertisement is herewith given:

The
STAGE COACH
Between
NEW YORK and BOSTON

Which, for the first time, sets out this day from Mr. Fowler's Tavern (formerly kept by Mr. Stout) at Fresh Water in New York, will continue to go the course between Boston and New York, so as to be at each of those places once a fortnight, coming in on Saturday evening and setting out to return by way of Hartford on Monday morning. The price to passengers will be 4d New York or 3d lawful money per mile, and baggage at a reasonable price.

Gentlemen and Ladies who choose to encourage this useful, new and expensive Undertaking, may depend upon good Usage and that the Coach will always put up at Houses on the Road where the best Entertainment is provided. If on trial the Subscribers find Encouragement they will perform the State once a week, only altering the Day of setting out from New York and Boston to Thursday instead of Monday morning. Jonathan and Nicholas Brown.

The first public vehicles mentioned as having been run in 1801 in New York City were the buss lines running from Bull's Head (near 26th street and Third avenue) to Manhattanville

and Harlem. In 1816 a stage line was established to run between 125th Street in Harlem and Park Row, leaving Harlem early in the morning, with a return trip in the afternoon—fare 25 cents. In 1820 there were several lines of stages from Bowery and Park Row to various sections of the city. These stages held the monopoly of the city's "rapid transit" business until the advent of the first horse-car line on Fourth Avenue, running between Prince Street and Bowery and Harlem River, in about 1832 (the population of Manhattan at that time being about 220,000). This line did not meet with public favor and was not successful, for it had to close down in 1837 for want of patronage and did not resume the horse-car traffic again until 1845, although there was an intervening steam-car operation. It evidently had the monopoly of this kind of traffic until a competing line came into the field, operating on Sixth Avenue, in about 1852. In the following year the Third Avenue line was opened, and from that year, or thereabouts, the street-railway trackage began to increase all over the country, for the U. S. Census shows that between 1850 and 1855 six horse-car lines were built in New York and other cities; between 1855 and 1860, 30 more were built; between 1860 and 1870, 30 more were built, and in 1890 there were in operation, in the leading cities of the United States, 876 horse-car lines. The later growth of the surface-car companies and the trackage in New York City is shown in the development of this paper.

Rapid Transit Elevated Lines—Manhattan and Bronx. The beginning of real rapid transit—when the first American rapid-transit baby was born—was the construction of the first elevated road in New York City, in 1867, on the east side of Greenwich Street from Battery Place to Cortlandt Street. This was an experimental section to demonstrate the possibility of "traveling on stilts" above the streets, with a new method of car propulsion, an endless chain operated over drums, and driven by stationary steam engines placed beneath the street surface.

As the population in Manhattan was rapidly increasing in this period, and in 1869 had reached the figure of 900,000 people, the need of a rapid method of traveling was becoming more acute and apparent; so in that year this short piece of single-track elevated structure was extended over the easterly curb

line of Greenwich Street and westerly curb line of Ninth Avenue, to Thirtieth Street, with a station at 29th Street, reaching out for business by making a close connection with the passenger terminal of the New York Central and Hudson River Railroad, their station at that time being located at Tenth Avenue and 32nd Street.

In 1871 the endless chain method for operating these trains was abandoned and dummies operated by steam were substituted. By 1876, the structures were extended, still on the west curb line of Ninth Avenue, to 60th Street, with the most northerly, and last to be built, station of the one-legged structure at 59th Street. By this time New York City, with a population of over 1,000,000 people, had fairly well established the fact that this kind of structure—an elevated road-bed and steam operation—had solved the rapid transit problem of the day and had come to stay. Other elevated railroad companies now appeared in the field, and elevated roads were being constructed or planned to run on many streets in New York City, subject, however, to the usual delays (injunctions) in building such structures; but notwithstanding these delays, in 1878, 1879 and 1880 the present elevated structures on Manhattan Island (with a population now of nearly 1,200,000) were in full operation, and later (1886 to 1891) extensions or connections with the Bronx were built. In 1891 the population of Manhattan Island was nearly 1,500,000 people; that of the Bronx about 89,000. In 1902 the population of the Borough of Manhattan had reached the very creditable figure of about 2,000,000 people, and that of the Borough of the Bronx about 250,000—an increase of nearly 300% in population in the Borough of the Bronx in less than ten years, entirely due to the introduction of rapid transit facilities and through inter-borough connections in that decade. In the year 1901-1902 the railroad company, to improve their method of operation on their rapid transit lines, abandoned steam engines and adopted the electric third-rail system, equipping all their lines in those years. The mileage for all the elevated lines—designated hereafter as the Manhattan Railway Division—was 37.68 miles of structure and 102.15 miles of passenger revenue tracks; these figures remained practically the same between 1902—1915.

Rapid Transit Subway—Elevated Lines. In the early seventies, the first passenger subway was secretly built under Broadway in New York City from Murray Street to Park Place, a distance of about 200 feet, and a car was fitted in this tunnel and operated by compressed air. After a few demonstrations and vainly trying to get a franchise for further extensions, the company, known as the Beach Pneumatic Railroad Company, went out of existence, the tunnel was abandoned and afterward used as a wine cellar. The car remained in its crypt until it rotted away. This tunnel was destroyed in 1912 in the construction of the Broadway section of the present so called Lexington Avenue subway—a survival of the fittest.

In 1903 the question of building real subways in New York City and the Bronx, made possible by the development of electric traction, was practically settled and subways were in course of construction, being financed and built by the City of New York. In October, 1904, with a great display of civic pride and demonstration typical of the city, the first subway, operated by the electric third-rail system, leased to and operated by the Interborough Rapid Transit Company, which furnished all the equipment, was opened to the public, and at that time extended from Brooklyn Bridge or City Hall to 137th Street and Broadway, New York City, a distance of about 8.5 miles. Other sections and extensions were rapidly added, and the present subway, designated hereafter as a city-built line, was finally completed and put in full operation in August, 1908. It extended from Atlantic Avenue in the Borough of Brooklyn to 242nd Street and Broadway, Borough of Manhattan, and to 180th Street and Boston Road, Borough of the Bronx. This line had 18.10 miles of underground tunnels, 1.46 miles of subaqueous tunnels under two rivers, and 6.16 miles of viaduct structures, making a total structure mileage of 25.72 miles, or a single passenger-track mileage of 76.18 miles, serving the Boroughs of Manhattan, Brooklyn and the Bronx; with over 25 miles of additional trackage to be constructed by the Interborough Company in Manhattan Division extensions and third tracking, and over 146 miles of subway and elevated city-built lines in Manhattan, Brooklyn and Queens being constructed jointly by the company and the City of New York—all practically under construction.

Hudson-Manhattan Line. In the same year, 1908, there was another important development of subway and tunnel construction. The Hudson and Manhattan Railway Company constructed a subway from 19th Street and Sixth Avenue, New York City, under Sixth Avenue and Christopher Street, tunneling under the Hudson River and thence to Hoboken, New Jersey, thus making a close and direct connection with all that large area of adjacent developed and undeveloped territory in New Jersey economically tributary to New York City and its rapid transit lines. This section of the tunnel was opened for traffic February 25th, 1908; extended to 23rd Street and Sixth Avenue, June 15th, 1908; and to 33rd Street and Sixth Avenue, November 10th, 1910. A "down-town" branch, which was opened July 19th, 1909, extended from Cortlandt and Church Streets under the Hudson River, with a physical connection with the Pennsylvania Railroad Station and other trunk-line stations in Jersey City; and still further reaching out, the company extended their line November 26th, 1911, running part way on the tracks of the Pennsylvania Railroad, into Park Place station, Newark, New Jersey. Total mileage operated in 1914:—main-line track in New York, 6.3 miles; in New Jersey, 9.4 miles; total main-line track mileage, 15.7 miles. Miles of road in New York, 3.16; in New Jersey, 4.75 miles; total miles of road, 7.91; the operating company owning both subway and equipment.

Brooklyn Elevated Lines. What improved traction has done for all the big cities of this country, it has also done for Brooklyn Borough, for when the first railroad franchise was granted in Brooklyn the population numbered less than 25,000; to-day that Borough has over 80 square miles of a populated area and nearly 2,000,000 people; every acre developed and every thousand added to its increasing population was made possible by the acquisition of increased transportation accommodations.

And this city went through the same transition in transportation development as New York City and some of our other American cities: first the stage lines, then the horse railroad, steam surface railroads, elevated steam railroads, cable lines, electric lines (surface and elevated), subways and bridges;

and this succession of transit facilities almost immediately preceded the transformation of undeveloped territory and unavailable lands into town lots, busy manufacturing districts, dwellings and beautiful parks.

The established and subsequent success of rapid transit elevated railways on Manhattan Island led to their adoption in the Borough of Brooklyn, and several lines were built between 1885 and 1890, Brooklyn having a population in 1890 of about 840,000. These lines were owned and constructed by different companies, and at first operated in districts not sufficiently built up and populated, working under many difficulties and troubles, at variance with each other, and did not begin to attain the quick popularity and financial success of the elevated lines in the Manhattan and Bronx Boroughs; but since these lines have amalgamated and been brought under one intelligent management, reducing the fares, and later acquiring a direct delivery of their passenger service into Manhattan by the operation of the Centre Street Subway loop, which was opened for business August 4th, 1913, and connecting the Williamsburg, Manhattan and Brooklyn Bridges, a showing in the next census (now being taken) of a still greater and more rapid growth of the population of Brooklyn is anticipated. The elevated lines and equipment were improved and are being still further improved, and the service bettered and extended. In 1900 the population of Brooklyn was about 1,167,000, in 1910 about 1,634,000, and in 1914 in excess of 1,950,000 people; and a great extension of its settled area has taken place, particularly in zones favorably adjacent to the lines of rapid transit facilities, present and proposed. Today Brooklyn has 58 miles of elevated roads with 105 miles of single track, and over 55 miles of additional trackage now under construction to be added to the existing elevated lines in Brooklyn, and 110 track miles of subway and elevated lines to be added in New York City and Brooklyn and to be jointly constructed by the City of New York and the Transit Company.

As indicative of today's and future problems of rapid transit in the Boroughs of Manhattan, Brooklyn, Bronx, Queens and Richmond, is their combined present population of nearly 6,000,000 people. The present increase is at the rate of 200,000

or more a year—or as the Health Department records show, a birth every four minutes and a death every seven minutes, the births exceeding the deaths about 160 in every 24 hours, all within city limits—with an estimated population for Greater New York in 1915, living within 19½ miles of New York's City Hall, of 7,681,546; the census now being taken will undoubtedly prove this estimate. The Borough of the Bronx heads the list with its percentage of increase in population. It has, today, 45 miles of navigable water front, seven railroad freight terminals, 4200 acres of parks, 50 miles of elevated, subway and steam roads, and 160 miles of trolley lines.

A comparison of all the boroughs in Greater New York City, as last recorded as to acreage, population, increase and density per acre, is shown in the following table:

Borough	Acreage	U. S. Census April, 1910	Population July 1, 1914	Increase in 4 Years	Percentage Increase Per Acre	Density Per Acre
Bronx*	26,522	430,980	641,980	211,000	49	23.9
Queens	81,720	284,041	387,444	103,403	36	4.6
Brooklyn	51,797	1,634,981	1,916,655	282,304	17	37.6
Richmond	36,600	85,969	99,186	13,217	16	2.7
Manhattan	13,226	2,331,542	2,538,606	207,064	9	191.9
Greater N. Y. C.	209,865	4,766,883	5,583,871	816,988	17	28.6

A quick deduction as to the cause of the differences shown in the table may be tersely stated, "Rapid Transit Facilities". Those boroughs having the best rapid transit facilities and cheap rides show the best results in both increase in population and building development, that is, where there is the territory to spread, develop and expand; and this applies to the two boroughs first on the list. The Bronx has its subways and its bridges and elevated roads and Queens has its new Queensboro bridge, with a direct connection into Manhattan of nearly all of its trolley lines, as a traffic entry. Brooklyn has many traf-

* Bronx County since Jan. 1, 1914.

fic entries, but is third on the list, because her elevated road facilities had not been improved to the standard of their capacity. Of late years, as heretofore stated, much has been done to improve that condition, and is still being done to all her transit facilities, and a greater population development is looked for in the near future. Richmond and Manhattan are last on the list, because, as to Richmond, it has an immense undeveloped acreage with meagre direct rapid transit facilities between boroughs—therefore, but little inducement to populate—with hopes, however, for a greater future in the operation of the new subway line extending under Fourth Avenue, Brooklyn, out in the direction of the Borough of Richmond and just a short distance farther, some day, under the Narrows into Staten Island.

Manhattan is last—the reason is obvious; over-congestion in population, with insufficient transit facilities, and possibly the main reason is that the bulk of business is done in Manhattan and is rapidly increasing. In the lower, central and even in the upper sections, business and pleasure centres have been established, dwellings have been crowded out to make way for the construction of buildings for business purposes and various municipal improvements; consequently multitudes of people are really compelled to seek more livable quarters, with little room to spread east or west on Manhattan Island, owing to its topographical layout. They go to adjacent boroughs to live—usually to the one best served by transit facilities and having the cheapest transportation.

This accounts for the phenomenal increase in population, in fact for all the present-day conditions in the Bronx; and the writer will later show in traffic figures how its population has increased closely following the entry of rapid transit—so note the dates. In the decade between 1880-1890 the population increased to 89,000; 1890-1900, to over 200,000; 1900-1910 to over 430,000, and at the present time is populated with over 640,000 people; the building operations and population jumps occurred almost simultaneously with the coming of new rapid transit facilities, or improvements of the old, into that territory. As shown by the following table, the building operations since 1902 are extraordinary and are an epitome of the wonderful effects

of rapid transit on an impressionable community with an undeveloped territory.

Year	Population	New Buildings	Value
1890	89,000	No record	No record
1902	227,544	818	$ 6,211,054
1903	241,788	802	6,537,859
1904	256,924	1610	21,061,910
1905	273,781	2242	38,186,720
1906	300,973	2284	28,648,030
1907	330,866	1998	21,271,449
1908	363,728	1812	19,861,225
1909	399,853	2255	37,163,110
1910	439,551	2138	46,884,055
1911	483,224	1346	22,536,910
1912	531,219	1285	33,845,325
1913	583,981	846	20,072,489
1914	641,980	735	16,347,382
1915 (Est.)	705,742	....	....

The writer mentions the Bronx Borough particularly, for its phenomenal and rapid progress illustrates one of the principal causes of the traffic congestion creating a rapid-transit traffic problem in Greater New York City. As the invariable result—and history repeats itself—wherever new rapid transit facilities are introduced in a borough, town or city, or improvements are made in present transit facilities, there is generally an immediate response by a building up of the locality served, a relative enhancement in property values, the population grows, and the rides, per capita, naturally increase. How the rides increased when new territory in Greater New York City was served by new rapid transit lines or betterments is illustrated in the actual traffic figures shown in the later development of this paper. In this year, 1915, Greater New York City has 375,037 buildings of various kinds, divided as follows: Manhattan, 84,849; Bronx, 35,163; Brooklyn, 172,380; Queens, 62,-525, and Richmond, 20,120. Manhattan alone has 813 office buildings, showing conclusively why the Borough of Manhattan must attract and hold the daily traffic movement.

Buss Lines in New York City. The buss lines of New York City are the antithesis of the trolley lines, and getting down to real facts, are really the survival of the stage coach lines operated in New York City in the early part of the 19th century.

The present lines have absolutely no physical likeness to the old-time coaches, but show a complete culmination in the progress of the art of traveling by stage coach. The Fifth Avenue Coach Company, incorporated in 1896 and succeeding other like companies, is the sole operator of stage lines in New York City up to the present time, and is *Sui Generis* in the transportation problems of the day. In 1912 the company had 81 motor busses, mostly double deckers, with an aggregate seating capacity of 2720 passengers (no standees allowed), and operating on several streets and avenues in Manhattan for a total distance of about 20 miles. In no sense can they be considered as competitors of any of the trolley lines, for they present a higher grade of public conveyance and charge a higher rate of fare. Their business is really to cater to the leisurely inclined public and to the sight-seer.

The routes laid out by the coach company for the sight-seer are made of especial interest to that class of rider by arranging the routes traveled along interesting places. Starting from the lower end of Manhattan, South Washington Square, they proceed north along avenues of special interest to visitors, who wish to see the town and many of the prominent and most interesting spots which are on the line. At times of important events or celebrations allied to New York City, these busses are particularly in demand; and perhaps the most attractive, and surely the most lucrative, route is the line along Riverside Drive, which parallels for some miles the Hudson River, with its many attractive sights and frequent events occurring on that interesting waterway. The busses are also routed to make a direct connection with the elaborate new station of the Pennsylvania Railroad; and traveling alongside of Central Park, they tap most of the interesting and instructive places of that beautiful area of 843 acres devoted entirely to public use.

The company shows an appreciable increase in business of late years, as indicated by the table of passengers carried since 1909. In 1915 the company operated about 150 busses, practically all double-decked and of two sizes; one holds 34 passengers, 16 inside and 18 outside, and another type holds 45 passengers, 23 inside and 22 outside. They charge a flat fare of 10c and give few transfers.

Year	Total Passengers Carried	Year	Total Passengers Carried
1909	3,609,304	1912	6,339,072
1910	6,305,175	1913	8,749,610
1911	5,997,372	1914	11,276,430

The Fifth Avenue busses carried over 700,000 passengers during the time of the recent event in Greater New York City, when the great Atlantic fleet of the United States was anchored in the Hudson River off Riverside Drive. The exact figure for the ten days was 705,512, an average of over 70,000 persons daily. This the company estimates to be about 50% over what the figures would be under normal conditions.

Surface Lines. The surface lines in Greater New York City did not begin to develop to a very great extent until after 1860. At that time the need for more railroad surface transportation had really become a necessity, and it was in that year that the legislature passed the well known ''Grid Iron'' act, which permitted the construction of surface lines on many cross streets in the City of New York; and the trackage increase was rapid and continuous from that year.

In 1915 there was recorded, in a Public Service Report, 1576.47 miles of car tracks as of June 30, 1914, which includes all classes of transportation—subway, elevated and surface—with a total number of 1,813,204,692 passengers carried, making about 337 rides per capita. For surface lines alone, Manhattan had 261.45 miles of track; Bronx had 211.76; Queens, 217.64; Richmond, 62.30 miles, and Brooklyn had a total of 627.59 miles of track (not divided). The lines in Manhattan are nearly all controlled by one company; but the lines, as a total, have a most complete grasp of the transit needs of the city; and have the most improved methods of electrical operation, whether underground, trolley or storage-battery. The cars are of the most scientific and approved type, and run on a roadbed but recently reconstructed; the electric conduit system was especially built to meet all the peculiar conditions of the City of New York, which it has developed in its surface transit operation. The surface lines in New York City had the usual transformations and experimentations which are perhaps common to other large cities in the development of means of car propulsion; as, horse,

cable, storage-battery, compressed air, gasolene, and finally the electric-conduit system, the final development of the art. The various dates of change of motive power on the New York City surface lines are interesting to note, for the various changes had their effect on passenger travel on the elevated lines; and what those travel changes were is indicated on a chart attached to this paper in its later pages. All the dates of changes in propelling power on different lines will not be stated, for want of space, but as a general statement, it may be recorded that between the years 1894 and 1898 the various north and south lines on Manhattan Island were changed from horse to cable, and between 1897 and 1902 the same lines were changed from cable to electric sub-trolley system. (The laws do not permit of overhead trolleys.) And this last change had considerable to do with traffic on the elevated lines, as will be shown later.

In greater New York City, the writer believes that rapid transit problems and other traffic problems are more difficult to solve than in other American cities; consequently, he has made that locality the principal feature of this paper, particularly Manhattan Island, the popular and logical business center, where the great passenger traffic movement originates and develops for a final distribution to its neighboring livable boroughs. Transportation problems are created there every day, and are rendered the more difficult to solve because of the narrow and confined limits of the Island and the eccentricities of the public demand for service, rendering it almost impossible at times to meet these conditions naturally and unnaturally imposed by the public in the use of its streets, in transportation and in vehicular traffic, moving everywhere—the congested movement of its throngs of people going everywhere and nowhere.

City of Chicago.

In this city the rapid transit system is entirely elevated and was built largely between the years 1890 and 1900, some years after the elevated lines were built in New York City and Brooklyn, and after those cities had demonstrated the general utility of elevated rapid transit lines for high-speed service. Chicago's particular problem in the construction of its lines was, principally, the wide and expansive area which must be

served by its transportation lines, and the location of its business area as compared with its living areas; and in this respect, the city is really one-sided. So in laying out rapid transit lines they had to spread in restricted directions, their four principal lines extending one to the north, one to the south and two to the west, with branches and offset lines. All of these lines come into a big loop, about two miles in circumference, embracing the principal business district and serving and controlling the quick traffic movement in that centralized business section of the city. Relay tracks with stub ends have been built adjacent to the loop to meet the public requirements for instant train service during the rush-hour period. All lines are operated by electricity, using the third rail system for current delivery; and express service is maintained by all lines during the rush-hour period. One of the unique public accommodation features of these elevated roads is the direct connections made with the large department stores along its lines, affording every facility for passengers using these lines to pass directly into these stores from the elevated stations; possibly a mutual benefit, but one of infinite benefit to the public.

The line extending northerly has a two- and four-track service for a distance of about 15 miles, and terminates at Wilmette, where it connects with the high-speed interurban lines, connecting adjacent towns and cities. This line crosses the Chicago River just north of the loop, and is built on public streets; though it is on private right of way for part of its length to obviate the necessity of building some bad curves in its structures. This is a construction problem not always easy to solve, because of the high value placed on real estate when the projection of a rapid transit line is promulgated.

The lines to the west extend about nine miles from the loop, and the line to the northwest about five miles, tapping the high-speed interurban service lines; some of these lines use the "L" structure, with a direct physical entry to the loop, thus making a direct connection between adjacent towns and cities and the business centre of Chicago. The west lines cross over boulevards and parks in seeming disregard of the rights of the public to their "breathing spots", such as obtain in New York

City or thereabouts, which restriction sometimes controls the logical and intelligent projection of a rapid transit line, though the latter may be of greater importance in itself to the public than the parks, comparing the number of people who use the former to the few who use the parks. In Chicago the "L" structures must have been there first.

The south line extends southerly with a three-track structure for about six miles, with further extensions and offset lines tapping the Union Stock Yards, parks and the Lake, and also making important trunk line connections. To the east of the loop is Lake Michigan, restricting the construction of elevated lines in that direction, but having transportation problems of its own, in close connection with all the lines of transit, and an important factor in the city's traffic and transportation problems.

The great number of public parks in Chicago have a total area of nearly 4000 acres, and the city's miles of boulevards, connecting these parks into one great system, are a great blessing to the people and a credit to the city, and incidentally are a benefit to all the railroad companies, for they are important "feeders" to a great transportation system. The elevated railroads have altogether about 80 miles of structure, with a track mileage of about 145 miles. The two street-car systems control over 900 miles of tracks, all operated within the city limits. These surface lines have only recently been reconstructed and transformed and are today the most modern and, in many respects, constitute the finest system in the world. One of the particular features in connection with these transportaion lines is—under a city ordinance passed in 1907—that the operating companies pay into the city's treasury 55 percent of what is figured as their net profits, and since the passing of this act, millions have been paid to the City of Chicago for its transportation privileges. This money is held as a nucleus of a subway fund, some day to be used for the construction of subways. The early fulfillment of this plan is now quite apparent and imminent.

The City of Philadelphia.

This city has a population today of over 1,600,000 people and an area of 129 square miles, including 4000 acres of parks.

In size it is the third city of the United States and the ninth in the world. Topographically it is somewhat akin to Chicago, for it has a development over towards its eastern limits and is, therefore, as unsymmetrical; also it has many of the minor problems and travel movements characteristic of that city. There are in Philadelphia many manufacturing industries, as centres, which have bred their own communities, thereby conserving and limiting traffic movement; and transportation necessities have heretofore been amply supplied with little effort.

The city is pretty well equipped with surface electric lines, which began as horse-car lines about 1858 and rapidly increased in their extensions and trackage, for in 1869 they had 129 miles of street surface tracks and today have nearly 600 miles of up-to-date electric service lines, by means of which every section of the city is easy of access from the business district. These lines have gone through the usual transformation—as in some other cities—in the character of propulsion, beginning with horse cars, then cable lines, electric lines, and finally, the Market Street Subway-Elevated Rapid Transit line. This line of about 7.5 miles length was built in the years 1903-06, and is one of the best and most thoroughly developed structures and systems. But it may be noted that Philadelphia, with its rapid transit lines, has at the present time about one half the track mileage of Boston, one tenth that of Chicago, and only one twentieth that of Greater New York. While Philadelphia was possibly deficient in its rapid improvements in the past, the requirements and necessities for high-speed quick-service trains spreading all over the city have not been so acute, for they do not have congested territories of population comparable with parts of other large American cities, and this is controlled largely by conservatism in their building methods.

Philadelphia is really a city of homes and not a city of overstocked tenements and apartment houses, for of the 350,000 buildings in that city, 315,000 are dwellings. But they evidently have traffic problems just the same, which must be solved, for only recently a $6,000,000 public loan was sanctioned by an overwhelming vote of the Philadelphia people—the money to be used to start immediately the construction of

rapid transit lines—and there is every prospect that Philadelphia will soon be abreast, or ahead of, some of her sister cities on the question of local transportation and high-speed transit facilities for her people. It is almost a certainty that aside from any pecuniary return on the investment, the city at large and the community in general will derive large returns in real estate and rental values; particularly, as the proposed lines will serve a territory not now fully developed, but tributary to the zone of proposed improvements and the business centers of the city.

The development of high-speed transportation facilities has had a very pronounced effect on the value of real estate in Greater New York City and in other large cities, and a similar effect must surely ensue in Philadelphia. The problems of transportation requirements for the city so far have been fairly well solved and rapid transit supplied by good steam railroads, their terminals being in the heart of the city; but the relative proportion of the traffic to be delivered by the transit lines to the delivery centers is not so great as in other large cities, so the problem is simplified. Market Street is the business center of Philadelphia and has a length of seven miles, extending from the Delaware River to the city line, and under this street, from the Delaware River to the Schuylkill River, is their subway—a subway-elevated line with a two-track road for its entire length. From the west side of Schuylkill River bridge to the east side of their City Hall the subway contains four tracks, the two outer tracks being used by the surface trolley cars, which make a loop around the City Hall, and after leaving the subway west of Twenty-third Street cross the Schuylkill River on a specially constructed bridge, branching off at the western end to the surface tracks on Market Street. The first section of the subway was officially opened Monday, December 18, 1905, by the operation of these surface cars from Fifteenth Street to the Schuylkill River.

Miles of lines elevated, 5.3; subway, 2.1; total, 7.4.
Miles of track elevated, 10.6; subway, 4.1; total, 14.7.

A small but very complete system of train and car service, electrically operated, serves as a means for passenger train and car movement from the east to the west side of the city,

and is part of a more complete transit system serving the entire city, including the steam trunk lines with their extensive and elaborate terminals.

The city of Philadelphia is washed by two rivers, the Delaware and Schuylkill, both navigable for large vessels directly to the port of Philadelphia; the transportation business developed on these rivers is a great factor in the development of the city and its transportation problems. The Department of City Transit of the City of Philadelphia is very active in the solution of the problem of rapid transit needs for that city, and is making a deep study of all conditions relating to the movements of the traveling public and car and vehicular traffic. In an attempt to solve those problems, a most complete and comprehensive set of reports and maps has been prepared, illustrating intelligently all the problems which have been encountered and the benefits coming to the general public upon their physical solution.

City of Boston.

In originally laying out a system of transit facilities in the city of Boston, evidently the greatest problem was the city itself; for the city's topographical characteristics are peculiar, its street layout, concentric as well as eccentric, being crooked and narrow and not comparable with any city street layout in the American continent. The direction of the streets from the central, or business, centre of the city may be likened to the spokes from the hub of a wheel, or to the radiating ribs of a fan.

Boston has a land acreage of 24,000. The acquisition of much of the increased acreage is due to reclaiming lands under water and annexing adjacent towns. Similar land ambitions obtain in most progressive large cities, and are really an imperative proceeding to meet rapidly increasing population and to solve the problem of congestion in an over-populated area. One of the grandest and most attractive parts of Boston—and one very important feature of her transportation problems—is the public park system. This is an unbroken chain of parks and parkways and boulevards extending from the north end of the city to the extreme easterly end, reaching Boston Harbor, and amounting to thousands of acres solely

devoted to the relief of her population of over 1,000,000 people. Boston is replete with many historic spots which create in the stranger visiting that city an incentive to travel about, and this particular incentive to travel on their many transportation ways is much exploited, with lucrative results.

The various transit lines serving the city and its suburbs cover a territory having an area of about 120 square miles in their daily operation; all lines converge toward the business section of the city, which is located at its northerly end and is contained in an area about one mile square, water bound by South Bay, Fort Point Channel and Boston Harbor on the east and north and Charles River on the west, the city proper extending and developing toward the south.

The evident fundamental and original intention of the originator of the car service was to supply a two-part system —surface lines and rapid transit lines—with short distance hauling in the center of the city, and the long hauls and fast riding through the outlying sections, made possible by overhead lines and subways. This was accomplished by building a very extensive system, comprising about 467 miles of surface lines, 30 miles of elevated lines and 17 miles of subway lines, the surface and elevated lines operating through tunnels in congested districts, where elevated or any kind of track structures were really prohibitive on the street surface. As early as 1893, a partial solution of the street traffic problem was being worked out in Boston by the commencement of the construction of a subway under Boylston and Tremont Streets, and some other streets, for the operation of the street surface cars. These were put in operation in 1898 and did much to relieve the terribly congested condition on the street surface. In the development of the rapid transit system, the elevated high-speed lines were built, reaching out towards Roxbury on the south and Charleston on the north, and joined by a loop, which partly embraces the congested business district and runs along the very busy easterly water-front on Boston Harbor, making close connection with the many ferries and steamship lines and the two important trunk line terminals. Many improvements of late years have been made in Boston's rapid transit and other lines; notably the building of the East Boston Tunnel, extend-

ing from Maverick Square in East Boston, under Boston Harbor, to Scollay Square in Boston. This improvement alone cost approximately $3,300,000.

The street cars and elevated lines pass all railroad stations and can be found at every steamship wharf or ferry, with cheap transportation and a wonderful system of transfers, with elaborate terminals for transfer of passengers from high-speed trains to the surface lines, going anywhere and everywhere; and today improvements are still being made for the betterment of its transportation service and congested conditions—street, subway or elevated.

City of Newark, New Jersey.

This city has been making ,great progress in recent years and has shown by an actual physical fact that she is an explicator of many of the disconcerting traffic problems of the day, and as such, deserves a place in history and the traffic hall of fame. Newark has an unconfined area of 23.4 square miles, of which 6.5 square miles are tide marsh and about 16 square miles populated area, with a busy population today of 366,721 people, an increase of 19,252 over the figures of 1912, according to the latest official census. Newark may be classed as one of the oldest cities of this country, for next year is the 250th anniversary of its settlement as a municipality. Its useful area had a gradual growth, made possible by the reclaiming of its marsh lands and annexing of adjacent territory as its population needs developed, until today it is the eleventh city in the United States as to its manufactures and the fourteenth as to population. It has a developed deep-water wharf frontage on Newark Bay and the Passaic River of 10½ miles, creating a water transportation problem of handling annually 3,125,319 tons of freight; and it also has a direct trunk-line service of 5 railroads, 14 passenger depots, with 900 passenger trains and 254 freight trains per day. Being within hauling distance of Greater New York, it has a close interchange of business interests with that city, and recently has added a quick-service passenger delivery and connection, by the advent of the Hudson and Manhattan tubes, bringing Newark within 18 minutes ride of New York City; it may well be stated that the former city is an important factor in the making

of problems for Greater New York City and a good "feeder" for its boroughs. Newark has a park area greater per square mile of territory than any city of the United States, which park area, with the sea-shore public camps, covers an area of 652 acres. These "play" spots serve as a great feeder for its 28 overhead trolley lines, which have a trackage of 875 miles, 105 miles within the city limits, and operate 663 up-to-date pay-as-you-enter cars, making 4259 daily trips through the city, with an annual passenger movement of 165 million riders, or an average ride per capita of 407.

The busiest trafficked four corners in the United States are at Broad and Market Streets. A ten-hour count made at those corners in the years noted and embodied in a report, dated June, 1915, issued by the City Plan Commission of Newark City, is particularly interesting as illustrating what a so-called busy corner really is like:

Four-corner Traffic at Market and Broad Streets.

Vehicles		Cars		Pedestrians	
1912	1915	1912	1915	1912	1915
12,791	18,923	6,104	5,861	279,891	246,724

This shows in the three years nearly 48% increase in vehicular traffic, a decrease of 3.39% in car traffic and a decrease of 11.85% in pedestrian traffic at these four corners.

The writer presents these comparative counts to illustrate how the re-routing of cars will affect traffic at any busy intersecting thoroughfare. Street traffic of all kinds had reached such a saturated condition at this spot that it was positively necessary that something be done to solve the problem and give traffic relief, and the decrease in the car count is due to the re-routing of three lines of cars so that in their revised operation they would not pass the four corners; and the decrease in pedestrian travel is explained by the statement that the people follow the trolleys in their street travel movements. The increased vehicular travel is due to a normal increase and also to a psychological cause—a new pavement, with the results, the power of suggestion, producing an incentive to vehicular travel. Apropos of this, another table, copied from the same report, is inserted as an interesting item, show-

ing the total vehicular traffic in busy sections of this city, and showing what problems might come to any busy city which fosters and promotes progress:

Total Vehicular Traffic. 1912—1915.

	Iron Tires	Auto Trucks	Auto-mobiles	Rubber Tires	Street Cars	Total
1915	69,471	15,322	72,463	7,342	43,483	208,081
1912	79,823	5,065	34,016	10,338	38,755	167,997
	—10,352	+10,257	+38,447	—2,996	+4,728	+40,084
Total Inc. or Dec. Per Ct.	—12.97	+202.51	+113.03	—28.98	+12.20	+23.84

In connection with the re-routing of these car lines, improvements have been made on miles of their trolley lines, extensions have been built, and numerous, commodious and well-lighted islands of safety have been constructed on streets which are busy with all kinds of traffic. All these things, already done, are not meant to wholly solve the problems of traffic in that city, but are only a means to an end, and that end, for a long time to come, to handle their car traffic. The hopes of the city lie in the building, on private property, of a municipal office and car-terminal building, with car loops in the building on the ground and second floors; cars from the west side of the city will enter by private right of way and subway to the lower basement loop, turn and go back again, and the cars from the north, east and south will rise to the second floor, go through the same operation, but reverse their direction on leaving. The building is located in the heart of the business section of the city near the new Park Place depot of the Hudson and Manhattan Railroad, the new rapid transit traffic entry to New York City. The solving of a complicated and perplexing transportation problem is therefore not remote, for the work is nearly two thirds done. It will cost about $6,000,000 to make all these improvements, but the money will be well spent, for the scheme is logically laid out and the benefits assured. The writer makes this statement with an assurance based upon experience in Rochester, New York, in July, 1907, where, after considerable study, a similar scheme was proposed by him for a solution of a surface-car transportation problem in that city. Newark, like New York City, is

going through an upheaval of some of its streets just now, and has been for some time past. In the latter city it is the subway work; in Newark, the construction of the Passaic Valley Sewer, an undertaking possibly not quite as important as a subway, but having the same results as to the temporary effect on surface transportation. When Newark is rid of this upheaval and the terminal finished, the traffic world will look to that city for the solution of some transportation problems; and if she will only go still further and solve the problem as to how to get rid of the ''jitney busses'', which are very numerous in that city, the traffic people in many cities will call her blessed indeed.

Many big American cities are seriously considering the problem of relieving street congestion by operating their transportation lines through sub-surface roadways. In all probability they must all come to this method of handling street traffic some day, for it seems to be the only solution of the problem. New York City has already considered this proposition, and the Municipal Art Commission of the City of New York has offered a prize for the best design for the segregation of different kinds of traffic, or of surface traffic, moving at right angles to each other, particularly at intersecting streets where there is so much traffic of all kinds as to really cause apprehension. There is many a like condition in many a like city, and it is only a question of time when we will be ''underground everywhere'' with all, or at least much, of our traffic.

MOVEMENT AND CONGESTION IN PASSENGER TRAFFIC, NEW YORK CITY.

When the first public conveyance, with its limited capacity for carrying passengers, was first used in New York City, congestion in transportation lines had its beginning, and, to a greater or lesser degree, how properly to care for the public in its transportation needs has been a problem ever since. This applies to the transportation of people, or of any commodity which may have a popular demand and which is necessary for the public use. It seems to be a fact, without any apparent explanation, that the less you have to give the public, the more the public demands that particular thing. There was

not much of a population in New York City when the first stage lines were introduced. These lines could not boast of many coaches; however, they had privileges not accorded to transportation lines of today, to wit: No franchise to purchase, no expensive road-bed and tracks to build, no transfers, ability to fix the rate of fare to suit themselves, and they were unhampered by any municipal body; but records show that they had their travel troubles.

The writer has of necessity confined many of the conditions mentioned in this paper to rapid transit problems within the limits of Greater New York City, although many apply to transit conditions in all of the cities mentioned, and many are universal. This great city with its population of 6,000,000 people or more, with a density per acre in population in some of the wards on Manhattan of nearly 700 people, and many nearly as dense, or an average density of population for Greater New York City of 28.6 people to the acre, is in spots the "hot bed of congestion" in buildings, living, transportation or street traffic, whether pedestrian or vehicular: of any kind of known congestion, mention it and Manhattan Island can produce the problem. Engineers are brought up on problems, have them all the time, delight in their solution; so when the need developed in Greater New York City, the solution of the Rapid Transit problem—providing adequate transportation facilities for public use—was put up to them. How intelligently they have responded and what they have done and what they are now doing along those lines is a matter of history and present record. After the building of the line, the railroad manager comes into the lime light, and from thence on it practically falls to his lot, and that of his trained lieutenants, to provide the public with the proper facilities for travel and to handle the crowds; and this must necessarily involve a wide range of study and experience, and, of necessity, a gradual approach to perfection.

In forejudging conditions of transportation in the construction of any new lines of rapid transit travel, and anticipating one of the important problems, paramount consideration should be given to what may be considered a certainty of a vast and swift growth of the community to be served, which

growth almost invariably follows the invasion of new rapid transit facilities, or even the improvement of old methods of transportation. After the road is built, if the transit companies appear to be behind-hand in supplying a demand of the public for better service, while carrying hordes of people back and forth each day from their homes and business, reversing the traffic movement every 24 hours, doing everything —by using every known method and improvement in railroading—to minimize danger and to conserve safety, that "behindhandness" is not an indication of unwillingness to give better service. As an illustration of this fact, you will observe in the Borough of Bronx how the rapid growth of population (figures heretofore given) in a community largely responsible for the transportation congestion on Manhattan Island affects the traffic figures (hereinafter stated) and proves the statement.

In looking backward, in Greater New York City, to the years immediately previous to 1904, the tunnel projectors must have reached a conclusion that in their plans all transportation needs in public travel movement for that city and its boroughs had been adequately anticipated and conserved "for generations to come", but it took only a few years of new subway operation to demonstrate that the tunnel had not been built large enough; and if our foresight was only as good as our hindsight, possibly such mistakes could not be made. But no one could have foreseen, in the development of that great public transportation utility, that travel requirements would be so much in demand in so short a time; for immediately after the subway was opened, a congestion of travel developed which was not in evidence or tangible when the tunnel was designed, and as a result, the capacity of the tunnel had to be enlarged, after it was in operation, at a great expense to the city. Such a condition as this was not evidence of an inability to solve a transit problem, but was a psychic condition, unexplainable, impossible of anticipating. The question of a psychological movement in the daily habits of the public, which the writer considers somewhat of a factor in rapid transit, will be made a separate subject in the further development of this paper.

The elevated lines were built in New York City in 1878-1880 practically as they now exist, when the need was acute for moving the public quickly, and the builders perhaps did not realize that in building these roads they were solving one of the transit problems of today. In 1877-1878, as soon as the New York Elevated Railroad Company started to build and extend their lines on Third and Ninth Avenue (under the general transit act of the laws of 1875), as a complete development of their limited acquired system on Ninth Avenue and Greenwich Street, which had then been in use since 1869 and had become by this time decadent, the Metropolitan Elevated Railroad Company, a successor in title to the Gilbert Elevated Railroad Company, which was incorporated under Chapter 885 of the Laws of 1872, started to build on Sixth Avenue and Second Avenue in New York City. Both companies had a franchise over the same right of way for part of the distance on the public streets of the city. In September, 1879, all the elevated rapid transit lines in Greater New York City merged into one great company, with perpetual grants for public transportation and with no restrictions as to municipal control. This company was named the Manhattan Railway Company, and is known today as the Manhattan Division of the Interborough Rapid Transit Company. The Interborough Rapid Transit Company leased all the elevated lines in New York City for a term of 999 years on April 1, 1903, the period dating from November 1, 1875, the date of the incorporation of the Manhattan Railway Company, with an agreement, in lieu of rental, to pay all the interest on outstanding bonds and 7% on the stock, with certain other small cash payments agreed upon.

For the purpose of a yearly comparison of traffic figures for the elevated lines, and showing how they fluctuate and are affected by their extensions or improvements, and by the entrance of competing subway lines and the improvements on the surface lines, reference is made to the following chart.

The writer has fixed upon the year 1880, indicated on the chart, because all the lines in Manhattan were in operation in that year. The year 1891, shown as the beginning of the Bronx Suburban line, was the date when it was first operated by the Manhattan Railway Company, although it began its first opera-

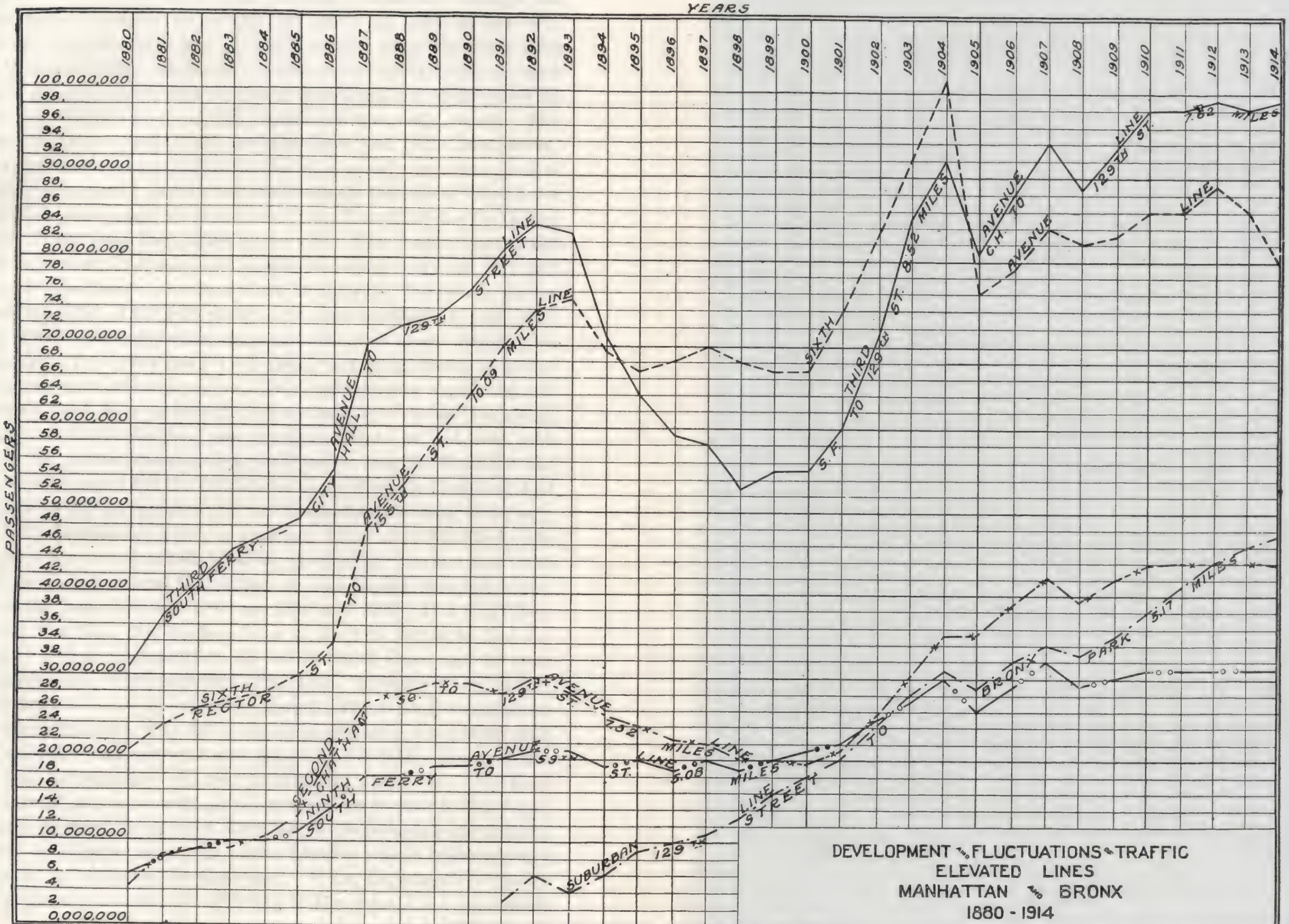

YEARS
PASSENGERS
DEVELOPMENT AND FLUCTUATIONS OF TRAFFIC
ELEVATED LINES
MANHATTAN AND BRONX
1880 - 1914
THIRD AVENUE LINE SOUTH FERRY TO CITY HALL TO 129TH STREET
SIXTH AVENUE LINE RECTOR ST. TO 155TH ST. 10.09 MILES
SECOND AVENUE LINE CHATHAM SQ. TO 129TH ST. 7.32 MILES
NINTH AVENUE LINE SOUTH FERRY TO 59TH ST. 5.08 MILES
SUBURBAN LINE 129TH STREET TO BRONX PARK 5.17 MILES
THIRD AVENUE LINE S.F. TO 129TH ST. 8.52 MILES
AVENUE C.H. TO 129TH ST. LINE 7.82 MILES
SIXTH AVENUE LINE

Plate I.

tion in 1887. The Third and Sixth Avenue lines may be considered as the two trunk lines, passing completely through the Borough of Manhattan on the east and west sides of the city. Those two lines have had all-night service since the beginning of their operation, which the Second Avenue and Ninth Avenue lines did not have; this accounts somewhat for differences in the curves indicated on the charts, in the early years. The Second Avenue and Ninth Avenue lines had little fluctuation, but the traffic chart indicates almost a steady increase in passenger movement, and shows conclusively that these lines have "a little movement all their own" unaffected by traffic things away from their own zones of service. The traffic figures for the Suburban line were not available before 1891, so only the travel movement since that date is shown. The chart shows that for 1891, 3,433,562 passengers were carried in and from the Bronx Borough, when its population was about 90,000 people; from that year until 1902 there was an increase in population of over 200,000 people. This increase was rapid and extensive, and is a practical demonstration of what increased transit facilities do to a new territory, or to an old one, with room for development and a progressive spirit. Between the years 1891 and 1902 the Suburban Rapid Transit Company had passed to the management of the Manhattan Railway Company, and in September, 1896, a through physical connection was made with the elevated lines in Manhattan Borough, with a flat 5c fare between Boroughs; so one would naturally look for a big jump in traffic between 1896 and 1902. But what happened was this: the surface lines in the two boroughs had begun to feel the competition of the elevated lines, and to meet that problem, they electrified their lines (between those years) and created a new incentive to travel. The transit methods on the elevated lines, with their steam propulsion, were rated as a thing of the past, and one may note how the traffic dropped due to the introduction of new competing facilities. To keep abreast of this new method of street surface travel, the rapid transit elevated lines were electrified—commencing about 1900—and an illustration of the traffic benefits which followed may be seen by reference to the chart. What happened to Bronx Borough may be seen by referring to the population and build-

ing table heretofore given in this paper; and from this table one will note that the population began to increase in jumps, and tremendous and marvelous building operations occurred. About this same period, namely, 1901-2, extensions were added to the Bronx division of the elevated lines extending from Tremont to Bronx Park, opening up new territory, and forming new and very busy communities. By thus electrifying the elevated lines, the disastrous results of a failure to keep pace with the advance of competing traffic facilities were obviated. All the elevated lines in the Borough of Manhattan had felt the depressing effects of the competing new modes of travel, but the traffic on the suburban line kept its upward movement. The lowest ebb of passenger movement for the other lines was between the years 1898-1900, when the yearly traffic, including all elevated lines of travel, was 174,000,000 to 183,000,000, and from then until 1904 the traffic on all elevated lines jumped tremendously. In that year (1904) the record shows a total of 291,147,487 revenue passengers carried, and this impulse given to traffic may safely be accredited to the new extensions, improved method of operation, increased facilities of travel, etc., and those very improvements have made a period in traffic history of the rapid transit lines in the City of Greater New York.

This is a most valuable illustration of how one rapid transit problem was solved, and a conclusive demonstration that an interval of stationary and depressing traffic is merely an argument for the needs of improved facilities and re-standardization of the plant.

This influence given to travel on the rapid transit system in Greater New York City may well be applied to rapid transit conditions in other boroughs and other cities, and the writer notes many like improvements that have taken place, and are now taking place, with similar results realized or in anticipation.

In 1904 the Sixth Avenue line alone carried over 102,000,000 revenue passengers, with the Third Avenue line a close second. The other lines were not doing such a big business but were holding their own and playing a waiting game. In the year 1904, and a little later for some divisions, the rapid tran-

sit elevated roads of New York City had reached the peak of their load; they had practically reached a surfeit, and hampered by unavoidable structural and track conditions, could not further expand in any direction. So the need of additional rapid transit lines was acute and apparent, and positively necessary; and the advent of these new lines was foreshadowed.

Right here it might be well to call to the minds of many of the readers who are familiar with traffic conditions, particularly in Greater New York City, the traffic prophecy of the day: "When the subways are built there will be no further use of the elevated lines"—how that has been fulfilled is shown by the traffic chart, which shows also the fallacy of the prophecy. In the total revenue passenger travel on the Manhattan Division of the I. R. T. Co. for 1914 there were 301,670,737 passengers carried, divided as follows: Manhattan Borough, 254,298,439; Bronx Borough, 47,372,298. The chart shows also that the control of passenger movement lies in Manhattan Borough. In the writer's experience the more rapid transit you give the public, the more it will serve you with its patronage; for many lines of communication, from any given center, will tend to increase the necessity for those lines. Many facilities of travel are a great educator, a great business maker, a great builder, a great common factor in community interests and in its development. In the latter part of 1904 the subway city-built line commenced operation in Manhattan, and a year later in the Bronx: notice by the chart how the indigested traffic fell off on the Third and Sixth Avenue lines.

The new and increased facility of travel offered by a competing line again hit the elevated lines, giving the passengers on those lines much relief and breathing space and lessening the then existing, almost unbearable passenger congestion, but creating a new problem to solve. About this time, however, all the high-speed transit lines came together under one management, and what traffic was lost by the elevated lines was gained by the subway city-built lines, the amalgamation of interests practically showing a balance of accounting, thus solving another transit problem. In 1908 the chart shows a falling off of traffic on all lines, due to a financial depression in New York City; such a condition is always reflected in railroad

travel. The public will ride when the necessity of business compels them, but will restrict the frequency of their rides when their nickels look as large as dollars. The chart shows that since the year 1908 the travel on this Manhattan Elevated Division is coming back to its own, with the single exception of the Sixth Avenue line, which shows a reluctance to come back—the downward trend of that curve for the last two years is caused mainly by the shifting of large business centres in the zone of its service. As an illustration of the quantity of travel in one day's work, in April, 1915, the elevated lines (Manhattan Division) carried 1,007,884 revenue passengers in 24 hours in the Manhattan and Bronx Boroughs.

To carry the multitude of people, it is necessary to provide a daily train and car service as follows:

Second Avenue Line—Intervals 2 and 4 minutes.

Length of trains (cars)	7	5	3	or 3176 car trips
Number of trains	232	188	204	or 624 train trips

Maximum service at one time in rush hours, 41 trains or 257 cars. No train service between 12 M. and 4:37 A. M.

Third Avenue Line—Intervals 45 seconds and 2 minutes.

Length of trains (cars)	7	6	5	3	or 7444 car trips
Number of trains	686	2	388	230	or 1306 train trips

Maximum service at one time in rush hours, 93 trains or 663 cars. Rush hour express service.

Sixth Avenue Line—Intervals 1 minute 12 seconds and 4 minutes.

Length of trains (cars)	7	5	4	3	or 4170 car trips
Number of trains	322	212	100	152	or 786 train trips

Maximum service at one time in rush hours, 51 trains or 333 cars.

Ninth Avenue Line—Intervals 1 minute 30 seconds, 4 minutes and 1 minute 45 seconds.

Length of trains (cars)	7	6	5	4	3	or 3464 car trips
Number of trains	144	186	22	72	314	or 738 train trips

Maximum service at one time in rush hours, 45 trains or 295 cars, with a one-way rush-hour express service.

New subways are now being constructed and rival transit companies are entering the broad rapid transit field in Manhattan, but their advent is looked upon with little concern, for that incident, at present, is somewhat remote. The elevated

lines having learned their lesson, are now spending over $30,000,000 in improvements and betterments, giving all their lines a complete through express and local service directly into and through the Bronx Borough, with added extensions reaching out for a physical connection with the present and proposed city-built lines, in course of construction, extending up to the city line. This will finally result in a continuous ride for the public (subway and elevated) from Atlantic Avenue, Borough of Brooklyn, to the city line, New York City, a distance of 21.50 miles, for 5 cents; and this great benefit for the public good is near its consummation. In Boston the transportation companies estimate that a profitable 5 cent ride for a passenger is approximately less than 4.25 miles.

Subways. From almost the date of their operating entry into the Boroughs of Manhattan, Bronx and Brooklyn, the subways were taxed beyond the limit of their capacity by the public, who were eager to avail themselves of a quick and new mode of travel. The subways, built for an estimated daily capacity of 400,000 riders, are today carrying on an average of over a million riders a day, and a recent record day shows 1,247,536 passengers. Originally 8-car express trains were operated at a 2½-minute interval and 5-car local trains at three-minute intervals; now 10-car expresses are operated at a minimum interval of one minute and forty-eight seconds, at a speed of 25 miles an hour including stops, and 6-car local trains at the same interval.

All trains and cars have the most up-to-date equipment of modern times, and this statement also applies to the tunnel and its equipment. In its daily operations it has created a world's traffic history all its own, second to none. The writer has frequently escorted through the New York subways noted governmental engineers and city officials hailing from England, France, Russia, China, Japan, Germany, Belgium, Austria, and many large cities in America, showing a world-wide interest as to how rapid transit problems are handled, and solved, in Greater New York City.

The rate of carriage per passenger is everywhere 5 cents, with paper transfers to the elevated lines at only one point, and body transfers to several points. A passenger now has a ride

of 17.5 miles for that five cents; or the length of a ride may be indeterminate, if one is inclined to beat the company. The total number of revenue passengers carried on all lines during the year ending June 30, 1914, was 661,886,671, an increase and a total gain over the previous year of 17,570,155. Of this increase the subway division had the credit of 12,941,593, the Manhattan Division, 4,628,562; the previous year, the Manhattan Division showed an increase of 2,574,165. It is interesting to note, while this enormous increase possibly reflects the development of the city in outlying sections along its subway lines, the Manhattan Division is not such a loser as one might presuppose, and the reasons are: The public has a choice of travel, the congestion of passenger travel in the subway, and an inherent common-sense desire on the part of some people to seek that transit thoroughfare which is the more comfortable, with comparatively little difference in quick movement.

To carry all this vast number of people on the subway city-built lines, it is necessary to provide a daily train and car service as follows:

Lenox Avenue Branch—Intervals 1 minute 30 seconds and 2 minutes 55 seconds.

Length of trains (cars)	10	8	6	5	4	3	or 7678 car trips
Number of trains............	442	70	254	158	36	80	or 1040 train trips

Maximum service at one time in rush hours, 72 trains or 592 cars.

Broadway Branch—Intervals 2 minutes 15 seconds and 2 minutes 55 seconds.

Length of trains (cars)	10	8	6	5	4	3	or 6064 car trips
Number of trains..........	224	140	254	156	40	80	or 894 train trips

Maximum service at one time in rush hours, 50 trains or 408 cars, or a maximum service, at one time, on the four-track trunk line south of 96th Street to Brooklyn Bridge and the two-track line to Atlantic Avenue of 122 trains, or 1000 cars, with a minimum interval of 1 minute and 48 seconds.

The traffic chart of the subway city-built lines, hereto attached, shows graphically how rapidly and to what extent the traffic has increased on that line, and indicates by a subdivision of the curves, into the different branches, how the traffic is distributed, and that the main artery of travel is the trunk-line in

Manhattan Borough. The control of traffic lies in that borough, and it is the business getter for all the divergent lines and branches. This illustrates very vividly, also, that the greatest amount of passenger travel emanates in Manhattan Borough, and proves to what extent the public use the rapid transit lines to go between their homes and business; and that business, all lying within Manhattan's limits, is ever growing and increasing and may some day occupy the whole of the island.

If space permitted, the writer could recite how all this vast multitude of people was carried on the elevated and subway lines, with the greatest care for its safety and despatch. The problems were manifold, but all were solved with good conservative judgment and management and astute decision; and it is well to note that the public may ride farther, swifter, and safer, and much more comfortably today, if they so desire, than ever before, and at the same price paid on the ancient horse cars.

STREET SURFACE CONGESTION.

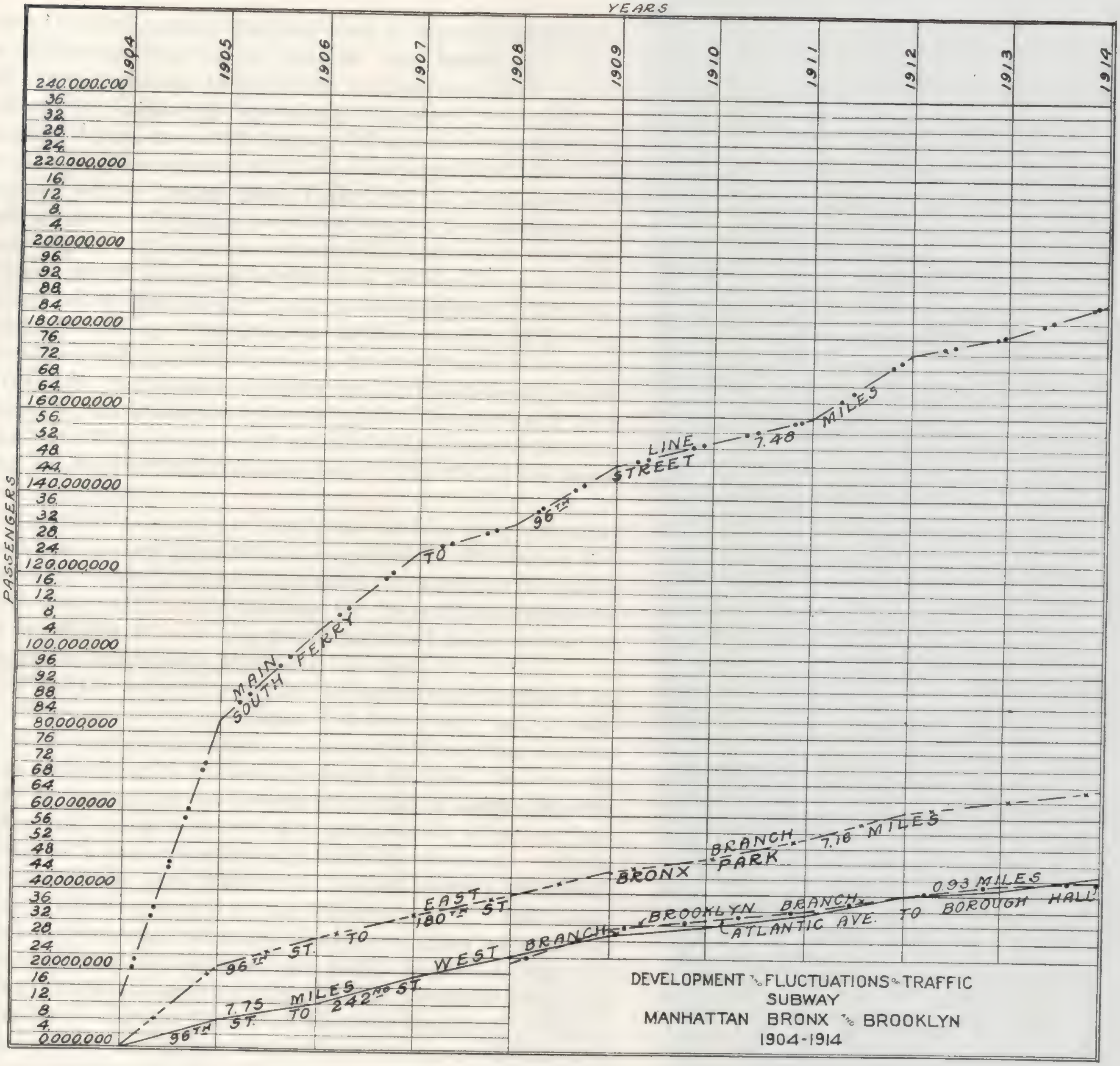
One of the difficult problems confronting the transportation companies today in all American cities, and notably in Greater New York City, is the increase in the vehicular traffic on the street surface. This perhaps has little to do with subway and elevated roads, but at the same time has a tendency toward affecting those ways of travel. The street surface transportation lines feel the effect more seriously, especially those lines which have to hold to their tracks. Coaches which may wander as they will, limited only by the width of the streets or avenues upon which they are required by their franchises to travel, do not feel it as much. Even this limitation is not arbitrary, for in the event of some accident or upheaval of the street on which they regularly travel, they may then cut around a corner and escape a possible serious impediment to a regular forward movement. Where there is a regulated street surface traffic, as in Greater New York City, they may be regularly re-routed for a short distance by the police—who have exclusive control of all vehicular movement in that city—and made to take a course, irrespective of a franchise route, which would best facilitate the forward movement of general street traffic, with no intent of favoring the buss line. This

is done to buss lines at many of the city's very busy corners, creating a free way to advance and make schedule time, thus having a distinct advantage over transportation lines, which are forced to stick to rails. The writer well remembers the day of horse-car travel in New York City. They did not have to stick to the rails then, for in the event of an impediment to car movement the usual thing was to "jump" the track, requiring a great effort on the part of the overworked horses and the consequent jolting and throwing around of the overwrought passengers. Those traffic problems cannot be solved in that way to-day, for obvious reasons.

The problem of regulating all street traffic in Greater New York City has of late years been a big one to solve and its continuing increase has taxed the patience of the transportation companies and the ingenuity of city departments having the slightest jurisdiction over streets; and in its broad field of study and arrangement, practically all the city departments are concerned.

As a result of combination, much has been done, or at least a great effort has been made, to control the movement of street surface traffic, for obviously, under the present laws, they cannot lessen or stop it. In this attempt to regulate and control traffic, the transportation lines are particularly concerned, for in estimating the carrying capacity of their tracks, considering the number of cars required to accommodate their business and pass a certain point, the character as well as the quantity of vehicular traffic must be given consideration and an economical arrangement and grouping of car units, with their routing, must be made to meet conditions. This necessitates constant study everywhere, for these traffic problems are almost universal and are becoming more complicated all the time.

In Greater New York City a great upheaval of the streets is now taking place in the construction of new subways. This applies to a greater or less degree in the Boroughs of the Bronx, Manhattan, Brooklyn and Queens, but particularly in Manhattan south of 59th Street. This is an added problem to confound the transportation companies, for miles of streets partly occupied by tracks are now torn up; and though only a tem-



YEARS
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
PASSENGERS
240.000.000
220.000.000
200.000.000
180.000.000
160.000.000
140.000.000
120.000.000
100.000.000
80.000.000
60.000.000
40.000.000
20.000.000
0.000.000
MAIN LINE SOUTH FERRY TO 96TH STREET 7.48 MILES
BRONX PARK BRANCH 7.16 MILES
96TH ST. TO 180TH ST. EAST
WEST BRANCH 96TH ST. TO 242ND ST. 7.75 MILES
BROOKLYN BRANCH ATLANTIC AVE. TO BOROUGH HALL 0.93 MILES
DEVELOPMENT AND FLUCTUATIONS OF TRAFFIC
SUBWAY
MANHATTAN BRONX AND BROOKLYN
1904-1914

Plate II.

porary condition, there has not been a fair opportunity for the surface car lines to do "the best they know how" under such an impediment to sufficient car movement. The new, scientifically developed, up-to-date, "stepless" and "pay-as-you-enter" cars have solved many of the minor problems of street car traffic in the many cities where they have been adopted, but in Greater New York City the development of their greatest utility has been handicapped by conditions already stated. A properly controlled car movement over such a large area of upheaved streets is a problem hard to solve, and the end of this difficulty is only coming in sight, after years of patient waiting. The stepless car has come in of late apparently to solve a minor problem for the women riders; but as the style and volume of skirts has again changed, the car without a step is now really a convenience for them and not a necessity. This applies to all cities; for fashions are not confined, but are rampant and changeable. This the writer knows from experience.

The double-decked car has been tried in some American cities, but is more popular in foreign cities. Its use on this side of the water is perhaps a matter of educating the public and is today still a live problem for the surface transportation companies to solve, as to its increased and general use as a public utility or a transportation unit.

When the writer was called to the city of Rochester by its "Business Men's Association", a few years ago, to suggest some equitable re-routing of its surface car lines (equitable as concerning its different business sections), he was surprised to learn after an investigation that a selfish business motive was trying to suborn a transportation situation, irrespective of a comprehensive city traffic development. All the surface car lines were found to be routed to serve practically one side of the city east of the "Four Corners", and a suggested improvement, relating to and forming an adjunct of a new trunk-line station, was also being controlled and confined to that same section of the city, already much congested, particularly on Main Street, its chief thoroughfare. Surface lines centered on this not over-wide avenue, crowded in with a large daily movement of light and heavy vehicular traffic,

creating much unnecessary congestion and retarding public betterment. There was no intelligent segregation or regulation of traffic, the west or growing side of the city was ignored and was not getting its share of trackage or car service or public improvement, and all from a selfish motive. This was a new figure to the writer in creating a traffic problem, but the answer was—relocate the station and re-route the cars so that all sections of the city would obtain a like benefit, such as conditions would warrant. Many changes were suggested and some made, which brought ultimately beneficial results.

In the rush-hour period of surface-car operation—and that hour seems to be expanding all the time—take any busy street in any live city; the headway of cars is seemingly reduced to such a period of time as will permit of consistent operation and may be called reasonably safe, and the curious spectacle is presented, in some cities, of an apparently continuous unbroken line of cars, stretching for blocks and blocks and moving along at a limited speed of about six miles per hour, no faster than the old horse-car lines. The cause of this slow movement in all cities may be ascribable to like causes, some obscure and some apparent. The apparent reason is the number, size and character of vehicular traffic, which is constantly increasing—in that respect subject to no municipal control. The logical solution of this problem requires a deep study, but the problem may be partly solved by more parallel streets, re-routing of car lines and the separation of all kinds of street traffic, creation of a one way vehicular traffic current, sub-passageways for a by-pass at busy intersecting streets, the intelligent regulation of traffic movement, greatest freedom to car movements, and the exclusion of the "jitney bus". These are not new ideas, for some such motives are now being worked out in New York City and in other large and progressive cities burdened with like conditions. In speaking of the "jitney bus", the transportation companies would better take notice that these "road bugs" are now being operated in over 100 different American cities with varying degrees of success, causing considerable trouble and loss to the legitimate traffic lines and becoming an added burden to the occupancy of streets. In Philadelphia a late report states that the Rapid Transit Com-

pany is losing $1,000,000 yearly in competition with the ill-regulated jitneys in that city. A good solution of this transportation problem is to get the infected municipality to sprinkle them with a "high license", which is sure death, for they have little vitality.

In Greater New York City, Broadway may well be considered one of the busiest thoroughfares in the United States, considering all kinds of traffic, and its busiest intersections are at Thirty-fourth Street, Forty-second Street and Columbus Circle. Other busy corners, for mainly vehicular traffic, are Thirty-fourth Street and Fifth Avenue and Forty-second Street and Fifth Avenue: if you ask the car traffic man, Forty-second Street between Madison Avenue and Fourth Avenue, and Sixth Avenue and Thirty-fourth Street are the worst; ask the policeman, and Forty-second Street and Broadway is the worst. For the busy corners, considering pedestrian traffic alone, Fulton Street and Broadway has 200,000 people passing in 10 hours, with Thirty-fourth Street and Broadway and Forty-second Street and Fifth Avenue as close seconds. These are all, possibly, the busiest sections in the United States, although Newark, New Jersey, claims the banner for the busiest street at her four corners, Market and Broad Streets. There are many more busy streets where it is no uncommon sight to see 50,000 people pass in 10 hours and vehicles galore, but there is no space to record such. The extent of the travel at the mentioned intersecting streets is shown in the following table from data obtained by a recent two-hour count.

	Cars	Vehicles	Pedestrians
Thirty-fourth Street and Sixth Avenue	822	2168	28,200
Twenty-third Street and Fourth Avenue	744	1700	20,000
Forty-second Street and Broadway	614	2129	30,000
Forty-second Street and Madison Avenue	532	1471	12,000
*Columbus Circle (one hour)	642	3259	(No count)

Many street problems are being solved, however, in many of our progressive cities by this combined working of the transportation companies and city departments, having as their respective stimuli the safety of patrons and that of the general

* While a busy place, it is not comparable with other busy spots, as there is plenty of room to manoeuvre.

public on the streets of the city; thus have been established many innovations and improvements for the good of the public. Many ordinances have recently been passed in New York City, and also in other cities, which positively further control and regulate the movements of all vehicular traffic under the regulation of the police, who, in the broad interpretation of their powers, are now seeking to control the transportation movements of the public, in some directions. These activities have much to do with transportation problems, and good results are indicated in many directions, with room, however, for further betterment. The innovations which the writer has particularly noticed, which clearly have to do with transportation problems and the safety of the public, are isles of safety, zones of safety painted on the roadway or fenced in, one-way vehicular movement, control of all traffic at busy corners, no left-hand turns, the "blazing" of a path across vehicular congested streets, guiding and limiting the movements of pedestrians, slightly raising of the road bed of car lines above the "free way" street surface, signs directing the movement of vehicles. The writer's attention has been called to the system of controlling vehicular traffic used in Detroit, Michigan, by the use of high semaphores under control of the police (more recently adopted in New York City), with red and green arms operating at right angles, with "Go" and "Stop" painted on them, and with red and green lamps at night. In Detroit, the growing street congestion problem has bothered the city for some years, and much has been accomplished lately in improving conditions by adopting common-sense methods and breaking away from old customs, and, incidentally, employing engineers. The population of that city is growing rapidly and at no distant date may reach the 1,000,000 mark; the vehicular traffic is increasing out of all proportion to the population increase, for this is the city that largely produces the trouble that mostly troubles—they manufacture and turn out 475,000 automobiles annually in that city alone. It is now really imperative that something be done to relieve their traffic conditions, and to that end, investigations and studies have been made and reports submitted by competent traffic engineers, members of one of the societies here represented, who have suggested many

inexpensive temporary expedients, as a measure of relief, to a $16,000,000 subway.

A control of the type and size of vehicles must be taken up in the near future, for one may notice today in all large cities a very apparent desire to increase the size so as to decrease the number of vehicular units, and the result has been the production of a vehicle which makes our old ones look like mere dwarfs. The big motor trucks with massive freight trailers coming on behind, enormous brewery wagons and "rubber neck wagons", and all sorts of mammoth business automobiles covered with advertisements and lights to attract public attention—with absolutely no limit as to size, nor breadth of tire—appear upon our streets, suggesting a day when our vehicular traffic will look like a mass of moving buildings. They certainly have a kind of commercial majesty about them which fills the eye,—particularly the eye of the transportation companies, who view with forebodings the advent of many such "babies"—and one may easily prognosticate what is going to happen to car movements and schedules in the future if these monsters of the land become really prevalent and rampant. A law went into effect in New Jersey last May—a model traffic law—which should be adopted in all states—a statute regulating the operation of all classes and kinds of vehicles on the highways, and prescribing the rights of everybody on the road, from the pedestrian up to the driver of the highest-powered motor car. This law supersedes all local regulations bearing on the subject, and its advantages are manifest. Much confusion of traffic movement and many accidents could be avoided in all large cities if the traffic laws and restrictions in each city were alike. This is particularly important with the many high-powered machines of today, whose area of travel is limited only by the amount of gasolene they may have access to. They are here today and in New York, Philadelphia, Boston, Chicago, Newark, Detroit or elsewhere, tomorrow, so to speak; and when you notice that the total registration in the United States for 1914 was 1,711,339, and for New York State alone 170,171, all of them motor vehicles capable of quick interchange between states and cities in their travel movements, we may well agree that the regulation of this class of vehicles

should be alike in all cities, or so regulated that there will be less inter-city traffic rule ignorance and confusion.

THE POWER OF SUGGESTION.

Psychology.

Some people think that there is nothing in the psychology of passenger movement, but those who say this are a long way from the truth. Psychology is the science of the phenomena of the mind, and what some of the traveling public do at times in their travel movements seems nothing short of phenomenal. The power of suggestion also has much to do with public transportation and traffic. This was illustrated in the great increase in traffic when the surface lines were electrified in 1898-1902, and also when the elevated lines were electrified, 1900-1902; for that increase was almost entirely due to the incentive given to travel in a suggestion to the public, by the widely advertised new methods of travel; and it was so when the subway was opened in New York City in 1904. There was a suggestion to the public that they could ride faster, better and more comfortably than on the elevated lines, and immediately a big rush of travel occurred, more than was figured on, with the result of almost immediate congestion in the subways and with the elevated lines rapidly losing traffic. The latter afforded a means of rapid transit where there was more comfort in traveling, moving along fairly rapidly as they had been doing for years, and with plenty of light and air; and the idea that must have been involved in the minds of the big majority of the public that the elevated lines were no longer necessary to them had no real foundation. Of course, much of the subway travel was natural and normal, and was due to the building up of the territories served, but thousands were crowding the new lines for no other reason than a psychological one—they really didn't know why they did it. In the crowding of trains and cars by the public, on any means of transit, there seems to be no reason, and the people seem to recognize no law but their own individual desire to get on board and to be the first one to reach—somewhere. This may be proved by watching the movements of the crowd in boarding the subway trains in Greater New York City at any of the

busy stations in the rush hours. They will push and shove, and their ability to board a train is limited only by the strength of the individual, the weaker ones being thrust aside and abused, or, incapable of resistance and unable to get out of the way, are rushed along with the stronger current of humanity, with many of the pushers showing the birth-mark of porcine tendencies. You may see a person at a reservoir station leave a comfortable seat on a less crowded local train, rush out of that car and across the station platform to take an already overcrowded express train, resulting in much discomfort to himself, to save, perhaps, a minute or two, and that minute to be lost in trivialities at the end of his trip. There is no explanation for this unnecessary movement except a phenomenon of the mind, which may be termed "minute madness". This same condition obtains at almost all the ways of travel in the rush-hour period, and the transportation companies are helpless in controlling it. When a Chinese Minister was visiting New York City some years ago he rode on the subway and saved a minute and a half in the way above stated: speaking of it as a great feat and saving of time, but regarding the minute and a half, he added, "Now that I've got it I don't know what to do with it". So it is with everyone who has this mental infection. If the transportation companies should attempt a coercive government of the habitual movements of the public, a revolt would certainly ensue; the public would fight for what they consider their ancient right, for they do fight if diverted from their desires or daily habits. In this respect the writer knows of no other country, in regard to transportation conditions, where the police have to be called upon to govern the travel movements of the public. An attempt to provide passengers with additional 17.78 inch seats has necessitated providing additional cars, but it is impossible to regulate the movements of the passengers when entering a car so that they will evenly distribute themselves over the length of the train and thus accommodate themselves and avail themselves of the seats provided and offered to them. They will crowd two or three cars and stand up for miles, when they could, by a little extra effort or judgment, reach cars on the same train which have perhaps numerous vacant seats, where

they could be more comfortable and contented. Why the public will not avail themselves of this freedom of relocating themselves is a real problem, for which psychological condition there seems to be no remedy. And again, we have our "bundle day" for a study. Few more difficult and embarrassing problems have come to the transportation companies, than how much, and what, passengers shall be permitted, besides themselves, to carry into our various street and subway and elevated cars. The bigger the crowd the bigger the bundle; and this is really no exaggeration, for a passenger will carry anything from a big bass drum or a big bass viol, or a box as big as a trunk, or an enormous monument of flowers like the "gates ajar"—possibly an emblematical suggestive tribute to a deceased regular rider—to a dog basket; all to be carried, including the passenger, for a stretch of miles for the one nickel, to say nothing of the exclusion of other passengers and the loss of other nickels by the taking of the room usurped by the so-called bundles. Many times these big bulky things are forgotten by the passenger when leaving the train—left on the cars—and sent to the company's lost property office. And some day, perhaps—and it is becoming more apparent every day—the masticated chewing gum, discarded by the passenger just before entering a train, will in time make a fine rubber carpet on the floors of the subway station and its stairways, which will materially limit the necessity for the much advertised rubber heel as a pedal adjunct; and that problem is: Why do they do it?—How to stop it—What to do with it—

The unexplainable various and frequent moving of the public in New York City, particularly in the congested districts in making a change of residence, is perhaps not generally known nor its importance appreciated; but the census men who are gathering statistics know all about it, for they have difficulty in acquiring accurate data, and oftentimes have to cover the same ground twice and compare notes with fellow workers before a proper deduction can be made. In a recent published report it is shown that New York City has a shifting population of 100,000 people who move their residences once a week; or nearly 5,000,000 people who shift their place of residence once a year. The reason may be "it is

cheaper to move than to pay rent''; but the writer believes that it is psychological, a mental contagion, but harmless to the public. Traffic served by stations at fixed points shows these changes in the fluctuation of the ticket sales, which make the rapid transit lines the real sufferers, because it keeps them guessing and is constantly an open problem. The elevated stations in the lower east side of the City of New York reflect this movement in the sale of tickets.

And so, many many things are done by the public in their travel movements which are incomprehensible—maybe minor things, but somewhat important—and cause one to ask, ''Why it is so''? And the answer is, all psychological,—one of the up-to-date transportation problems. Professor Swain, of Harvard University, in a recent address advised young engineers to ''broaden their horizon by taking an interest in history, literature, psychology and other lines which give a grasp on the problems of life''; and the writer suggests that, for a complete development of the study of psychology, a good field to work in is the one now occupied by the transit companies, with their various transportation problems in any city. A correct solution of any problem depends primarily on a true understanding of what the problem really is; and one great traffic problem is already solved if you have the public with you.

The writer would state in conclusion that transportation problems have many sides—many remote from the engineers' general practice, where the slide rule and mathematics are the usual solver—so he has in preparing this paper taken up a subject possibly outside of an engineer's usual province, but surely within the scope of any engineer who seeks to broaden and extend his line of work; and he also considers that a legal and business training, as well as an engineering training, is essential to the engineer who is progressive, ambitious to qualify along all lines, and who desires intelligently to respond to all demands and to solve all kinds of problems where primarily the engineer is best fitted to serve.

The writer desires to acknowledge his indebtedness to the following bodies for help and information in preparing this paper: American Society of Civil Engineers; American Elec-

ric Railway Association; Historical Society of City of New York; Public Service, New York City; Public Service, Newark, N. J.; Public Service, Boston, Mass.; Transit Commission, Philadelphia, Pa.

DISCUSSION

Mr. O'Shaughnessy.

Mr. M. M. O'Shaughnessy,† M. Am. Soc. C. E., opened the discussion by first noting the relative cost of double-track line as follows:

Surface lines	$ 215,000
Elevated lines	800,000
Subway lines	3,500,000

He then pointed out that the average speed of surface cars in San Francisco is 8 miles per hour, and it therefore takes about 35 minutes to get down town from the residential district. By elevated lines this could be reduced to 15 minutes. This would be a saving of 40 minutes a day (two trips), and assuming the average wage at $0.15 per hour, the saving would be $0.10 a day. This amount for a large community would warrant a considerable investment in an elevated line. Philadelphia has a very satisfactory double-track elevated road.

He maintained that in spite of the adverse criticism and remarks to the contrary, San Francisco's municipally-owned surface lines have been a very great success. (40 miles of single track.)

Referring to ventilation, he pointed out that the ventilation in the New York Subway is defective. It is good near the portals and exits, but at other points the air is stifling. At first the subway attracted patrons, but they are gradually going back to the elevated car lines.

In the Twin Peaks Tunnel, San Francisco, the question of ventilation was seriously considered. Fans and a positive system of ventilation will be installed. All the air can be withdrawn, thus insuring a positive circulation. No subway is desirable which does not take care of the health of the people.

Mr. Kriegsman.

Mr. E. F. Kriegsman,* Assoc. M. Am. Soc. C. E., called attention to the danger of depreciation in the value of property adjacent to elevated roads due to noise. This nearness of buildings to the elevated structure depends on the width of the street and the width of the structure.

In New York the structures were light and limber and the whole structure swayed when a train approached. Ties were fastened directly to the steel work, the noise was transferred from the tie to the structure, and from there to the surrounding air.

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Prof. Cory.

Prof. C. L. Cory,†† Fel. A. I. E. E., pointed out the two great counter influences regarding centralization of population in most cities: (1) the apartment house; (2) the outlying residential district.

In San Francisco a different problem is presented, that of unloading a large number of individuals from cars into ferry boat, and vice versa, thus accentuating the congestion.

Referring to noise due to trains on elevated structures, he noted that when Boston built their elevated roads they used heavier metal, with concrete footings, making the whole structure much heavier. The ties were fastened to wood stringers, which eliminated considerable amount of noise and vibration. At the beginning there was little profit in the line; likewise, property owners on Washington Street objected to the noise. The cars were therefore remodeled, with a decided improvement.

In the Chicago elevated, the ties were rock ballasted (almost as much as for a steam railway). It was not as noisy as the Boston line, but the cars were more noisy than the eastern cars.

The Philadelphia elevated is the most modern. The streets are much wider and this helps to reduce the noise.

Mr. Baker.

Mr. Chas. W. Baker,** Mem. Am. Soc. M. E., noted that a third track is being added to all New York elevated roads. They were originally built with such a large factor of safety that it is not necessary to add any more metal to the columns or their members to take the additional load. This is remarkable, considering that the road was built forty years ago and has been subject to extraordinarily heavy traffic, surpassing, in fact, any in the world, and yet it is good for additional load. The third tracking is being done under the best care and inspection.

Philadelphia is proposing a new design of elevated road. This consists of one broad, single column in the center, supporting the entire structure. This compact plan increases the lighting of the street and is amply stable, due to the spread foundations used. The cost of this new type is less than the old system having columns at each curb.

He approved of the need of revising plans of the rolling stock to reduce the noise. In both surface and elevated lines, the design of the rolling stock has lagged far behind the needs.

He called attention to the remarkable service rendered by German surface roads and expressed the opinion that the average American surface system cannot compare with them. They have fixed stopping places, whereas American cars stop at each corner. In Germany the stopping places are marked by plain, neat signs. In America the stops are unnecessarily frequent, causing dissatisfaction and delay.

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Paper No. 53

RECENT PROGRESS AND TENDENCIES IN MUNICIPAL WATER SUPPLY IN THE UNITED STATES.

By

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The establishment of Engineering Congresses in connection with our International Expositions, affords a notable opportunity to review the progress of the varied lines of engineering represented, and establish milestones of progress, so to speak. It is interesting to note that the past International Expositions at which Engineering Congresses have been held, have, so far, in this country happened to occur a little over a decade apart; that of the World's Columbian Exposition, held in Chicago in 1893, being succeeded by the Louisiana Purchase Exposition in St. Louis in 1904, and again by the Panama-Pacific Exposition of 1915.

It will be the purpose of this paper to review, as nearly as possible, the recent progress and tendencies in municipal water supply in the United States since the Engineering Congress of 1904.

WATER SUPPLY DEVELOPMENT.

Important work has been done in the development of sources of water supply. The greatest interest attaches to recent large gravity supply developments of very remote surface sources. Two such projects of unprecedented magnitude and importance have been carried almost to completion within the past ten years, and a third has been developed to the point where construction will be possible in the near future.

The Catskill Supply.

The greatest single municipal water supply project so far undertaken, is the Catskill supply for New York City. This project is designed to furnish 250,000,000 gallons per day as

first completed, at a cost of about $200,000,000, and will be capable of enlargement to supply 500,000,000 gallons per day.(1)* The need for such a supply was foreseen as early as 1900,(2) and led, after exhaustive investigations,(3, 4) to the beginning of construction in 1906. Impetus was given to the work by the drought and threatened water famine of 1911,(5) and completion of the entire undertaking is now expected in about a year.

Los Angeles Aqueduct Supply.

The city of Los Angeles, in 1913, carried to virtual completion the largest single water supply project conceived and finished within the decade just past. This work, for boldness of conception and speed and economy of execution, is an excellent demonstration of the possibilities of municipal enterprise.(6) When, in 1904, Los Angeles faced the prospect of outgrowing its municipally owned water supply of 40,000,000 gallons per day, the first definite steps were taken to secure an adequate supply for future needs. It was decided, after thorough investigation, to develop a gravity supply from Owens River,(7) 250 miles distant, and construction of the great aqueduct began in 1907. This aqueduct, now completed,(8) insures to the city 259,000,000 gallons per day of mountain water at a cost of $24,500,000, exclusive of power development. All water in excess of the city's present needs will be sold for irrigation,(9) and the great height of the source (3,812 feet) permits of several water power sites from which the city expects to derive additional revenue.(10)

Hetch Hetchy Project.

The way has been paved during the past ten years to practically insure the construction in the near future of another great municipal water supply project, very similar to and rivalling in magnitude the Los Angeles aqueduct. This is the Hetch Hetchy project proposed for the future water supply of San Francisco and the adjoining bay cities. This project, as now planned,(11) involves a gravity aqueduct 170 miles long, of 240,000,000 gallons per day present maximum capacity, and storage on the Tuolumne River sufficient to provide a present

* The figures in parentheses refer to the numbered citations in the appended bibliography.

minimum supply during the driest year of 160,000,000 gallons per day, at an estimated cost of $36,981,000. The ultimate capacity of the project is to be 400,000,000 gallons per day, and the great altitude of the source (3,800 feet) makes possible three water power sites along the route of the aqueduct.

The checkered career of the Hetch Hetchy project is explained largely by the fact that San Francisco is supplied at present by a private water company,[12] whose water supply resources are not as yet fully developed;[13] that there are several other available sources of supply; that the proposed project must in part involve the development of a supply on government lands, and located in a National Park, and that the riparian rights of irrigation interests on the same river are involved.

Other Water Supply Developments.

The recent development of the larger supplies drawn from the Great Lakes has been influenced by the attempt to eliminate turbidity, and to secure more uniformly potable water by extending intakes to greater distances from the shore and to greater depths of water. Chicago,[14, 15] Milwaukee,[16] Cleveland,[17] and Buffalo[18] have attempted in this way to improve their supplies. Some benefit has been secured, but the remote intake does not insure pure water and does not give entire relief from turbidity at times of great storms.[19] With the increasing pollution of the lakes, and the growing demand for pure, clear water at all times, the tendency of thought at present is towards the filtration of lake supplies. This tendency is shown by the use of filtration at Niagara Falls, N. Y.; Sandusky, Ohio; Erie, Pa.; and more recently at Evanston, Illinois; Cleveland, Ohio, and Toronto, Canada.

Many of our large cities continue to draw their water supply by pumping direct from near-by rivers, and the increase in quantity of water used from this source has been very considerable during the past ten years. The water supply problem for these cities has been greatly simplified by the present efficient methods of water purification, and practically all of our important river cities using river water have within the past ten years resorted to filtration. Among these cities are New Orleans, St. Louis,[20] Minneapolis,[21] Louisville, Evans-

ville,(22) Cincinnati,(23) Pittsburgh,(24) Philadelphia,(24) Washington,(25) and many smaller cities.

There have been many recent extensions of ground water supplies throughout the country, although the development of this source of supply has been advisable as a rule only in the smaller cities, and on a comparatively small scale. In some cases, as at La Crosse, Wis., a ground water supply has been developed, and the river supply abandoned to avoid filtration. In other cases, as at Des Moines, Ia., a satisfactory ground water supply has been extended, in preference to developing a river supply, with filtration. In still other instances, as in the case of the bay cities of California, ground water supplies have been extensively developed to supplement a very scant impounded supply, in a region where no rivers for water supply are available except at great distance.

With the continued growth of our urban population and the high rate of water consumption so characteristic of American cities, the problem of an adequate source of supply will continue to be a vital one for many of our cities, which are, as a rule, provided only for the immediate future, and will before many years, outgrow their present supplies. In certain sections of the country the limited water resources are without doubt a serious handicap to cities already existing, but where the growth of the city is sufficiently sustained we may expect to see other great water supply projects undertaken as at New York and Los Angeles.

QUALITY OF WATER FOR MUNICIPAL SUPPLY.

Great improvement in the quality of the water furnished in many of our cities has been brought about during recent years by the introduction of supplies from pure sources and the purification of suspected supplies. The best general index we have of the extent to which our water supplies are better today than ten years ago, is still furnished by the typhoid fever death statistics, cautiously used. The typhoid death rate has, in nearly all cases, been greatly reduced, but in considering the effect of purer water supplies on the typhoid fever death rate, we must make due allowance for the decline in typhoid fever deaths from other causes now active.

It has been shown by Mr. George A. Johnson, M. Am. Soc. C. E., that we may reasonably attribute to water purification an average reduction of 16 deaths per 100,000 population in the thirty-three cities of over 100,000 population in 1910, that have introduced some form of artificial water purification.([26]) On this basis 2,600 typhoid-fever deaths are now avoided each year in these cities alone, and the saving in typhoid fever cases is estimated at 39,000 a year for these same cities. These conclusions are based on the typhoid statistics for the period 1900-1912, by comparing the average rate for 1900-1908 with the average rate for the period 1909-1912. Considering the increase in population supplied with filtered water since 1912, and the large number of cities and towns under 100,000 population having some form of water purification, it is evident that the above estimated saving of 2,600 typhoid fever deaths per year is probably much below the present total annual saving that has been brought about by the progress of water purification in the past ten years.

But the sanitary quality of our water supplies has also been generally improved by the close attention given to their quality in recent years, and the higher sanitary standards which an educated public has come to demand. More care is given to the protection and policing of watersheds, to the protection and cleaning of reservoirs, to the accidental contamination of lake supplies from shipping, and to the accidental contamination of surface supplies from railroad trains. Well protected ground water supplies have been sought for diligently as a superior source even to filtered surface waters, which depend, to some extent, on human vigilance for their purity, and the protection of ground waters and even deep well waters has been carefully studied. In all of these ways our general standard is higher and our water supplies distinctly better than they were even a decade ago.

A number of cities having supplies of naturally very hard waters, like Columbus, Ohio,([28]) have in recent years installed water softening plants as well as filtration, while at other plants iron removal, or removal of color, is accomplished as part of the purification process.

WATER FILTRATION.

Stimulated by wide dissemination of modern ideas of sanitation, water filtration in the United States has made great progress during the past decade. The population supplied by filtered water, as shown by Table 1, has increased from 3,160,000 in 1904, to 17,291,000 in 1914. As late as 1903 only about 60 cities and towns were supplied with filtered water, while there are now some 480 filter plants in this country with a total capacity of 2,585,000,000 gallons per day. These filters serve 40.68 per cent of the urban population, while in 1904 only 9.66 per cent of the urban population (including all towns of over 2,500 population) was so supplied.[28]

The relative growth of slow sand and rapid sand filtration during this period is interesting. It reflects strongly the relative adaptability to conditions in this country of the two types of filters and the gradual acceptance by the general public of ideas in water purification looked upon with prejudice less than ten years ago. Although slow sand filters were the first to be introduced, by 1904 rapid sand filters, including the earlier "mechanical" filters, were far in the lead with a total population served of 2,600,000, as against only 560,000 supplied by slow sand filters. From 1904 to 1908, several very large slow sand filter plants were completed, at Philadelphia, Pa., Washington, D. C., and at Pittsburgh, Pa., and the relative lead of rapid sand filters was much reduced, although even then the population served by rapid sand filters was very nearly twice that supplied by slow sand filters. Since 1910, the growth of slow sand filters has been less marked. In 1914, a population of 5,398,000 received water from about thirty slow sand filters, while upwards of 450 rapid sand filters supplied a total population of 11,893,000.

Although there are now in this country fifteen rapid sand filter plants to one slow sand plant, the capacity of the larger slow sand filter plants is greater than that of any rapid sand filters yet built. The largest slow sand filter, located at Philadelphia,[28] and in service since 1908, has a rated capacity of 240 million gallons per day. In contrast to this, the rapid sand filter at Cincinnati,[28] completed in 1907, with a capacity of but 112,000,000 gallons per day, is the largest plant of this type

TABLE NO. 1.

Growth in Population Supplied with Filtered Water in the United States by Slow Sand and by Rapid Sand Filters. ([28, 34])

Year	Total Urban Population in the U. S. (Towns and cities above 2,500)	Pop. Supplied with Filtered Water			Percent of Urban Pop. Supplied		
		Slow Sand Filters	Rapid Sand Filters	Total	Slow Sand Filters	Rapid Sand Filters	Total
1870	....	None	None	0	0.00	0.00	0.00
1880	13,300,000	30,000	None	30,000	0.23	0.00	0.23
1890	21,400,000	35,000	275,000	310,000	.16	1.29	1.45
1900	29,500,000	360,000	1,500,000	1,860,000	1.22	5.09	6.31
1904	32,700,000	560,000	2,600,000	3,160,000	1.71	7.95	9.66
1910	38,350,000	3,883,000	6,922,000	10,805,000	10.13	18.05	28.18
1914*	42,500,000	5,398,000	11,893,000	17,291,000	12.70	27.98	40.68

* Compiled January, 1914, by George A. Johnson.

in operation up to 1915. Present tendencies in this country are indicated by the fact that several cities are now building mechanical filter plants larger than any now in operation, while no large slow sand filter plants are under construction or projected. A rapid sand filter of 320 million gallons capacity, 30% larger than any existing slow sand plant, has been designed for the Croton water supply of New York.(30) St. Louis is building a rapid sand filter of 160,000,000 gallons capacity,(20) the city of Cleveland is building two rapid sand filters,(31) with a combined capacity of 225 million gallons, the larger plant of the two having 150 million gallons capacity, and Baltimore(32) is about to complete a rapid sand filter of 128 million gallons capacity.

The rapid sand filter has outstripped the slow sand filter principally because it is better adapted to handling waters of the high turbidity characteristic, at times, of practically all our rivers outside of the extreme northeasterly portion of the United States. In many parts of the country, the slow sand filter, unaided by auxiliary processes, more especially coagulation and preliminary sedimentation, would be incapable of continuously handling the water except at greatly reduced rates of filtration,(33) owing to the rapid clogging of the beds and great difficulty and time required in cleaning. The rapid sand filter, using coagulation and ample preliminary sedimentation that relieves the filters proper of a very large share of the burden of purification, and with easy means of cleaning the filter beds, has, on the other hand, repeatedly demonstrated its ability to properly and economically filter the most turbid waters. The growing recognition by engineers of the merits of the rapid sand filter is evidenced by the final recommendation in a number of instances of rapid sand filters, reversing earlier recommendation of slow sand filters, as in the case of New York City,(30) Baltimore,(32) and Minneapolis.(21)

Although the limitations of slow sand filtration in handling waters of high turbidity were early realized,(34) these filters were often favored in preference to rapid sand filters. Popular objection to rapid sand filtration arose on account of its use of a coagulant. This prejudice is well illustrated in the case of Washington, D. C.,(35, 36) where popular agitation resulted in

the building in 1905 of a slow sand filter after the original recommendation of a rapid sand filter.([28]) Prejudice against the use of alum, and, in fact, against the use of other chemicals, either for coagulating, softening, or sterilizing water has now been for the most part overcome. This is mainly due to the extensive use of coagulation at a large number of rapid sand filter plants, occasionally in conjunction with water softening, without ill effects on the consumer, and to the well earned public favor enjoyed by the process of water sterilization by means of hypochlorite of calcium.

While the rapid sand filter has overcome the prejudice under which it labored ten or fifteen years ago, and has been demonstrated as equal, if not superior, in bacterial efficiency to the best slow sand filters, it is of interest to note that the attempt in recent years to apply slow sand filtration outside of its proper zone of relatively clear natural waters has not met with success. This attempt has brought about very radical departures from early slow sand filtration practice, and has obscured the original sharp distinction between this type and the rapid sand filter, without evolving a superior filter. It has been necessary to resort to coagulation at the Washington slow sand plant, in spite of very long preliminary sedimentation. At Philadelphia([28]) and at Albany,([28]) preliminary filters, which are practically rapid sand filters, have been added to better enable the slow sand filters to do the work originally expected of them. At Pittsburgh([28]) extensive modifications have been necessary to properly prepare the water for the slow sand filters that had been proved incapable, alone, of producing a satisfactory effluent. The reliance now placed on sterilization of the filtered water at most of the principal slow sand filter plants shows further the wide departure made from the original slow sand process,([28]) in the effort to keep the performance of some of these plants up to the standard originally intended of them without the help of these and other auxiliary processes. All of these processes are foreign to the original idea of a "natural" process for water purification, which gave to the slow sand filter much of its vogue and played an important part in meeting the early competition with the so-called "mechanical" filter and the present rapid sand filter.

The process of rapid sand filtration was highly standardized ten years ago, and has undergone little change since 1904 beyond the incorporation of water sterilization as an additional safeguard, and a more general appreciation of the importance of preliminary sedimentation. Filters of this type follow closely the lines of the original modern rapid sand filter built in 1902 at Little Falls, N. J.([37])

Although it is well understood that any filter has a definite limit of capacity beyond which it is not possible to obtain properly purified water, there is a tendency to operate filters at greater than the safe rates, as the plants are outgrown. The danger in this practice is evident, and engineers generally are disposed to discourage it, and, so far as possible, to anticipate it by designing with ample provision for the needs of the immediate future, and with special attention to facility for making future additions.

There is a further tendency of late to overconfidence in filtration as a preventive of disease, and a disposition in some quarters to attempt the filtration of badly polluted waters in preference to more expensive and distant sources. The engineer and the sanitarian of today are engaged in pointing out that it is not a proper or wise policy to overload water filters from a poor source of supply.

The field of possible application of water filtration, and more particularly rapid sand filtration, is today a very broad one. Practically all river and large lake municipal water supplies,([27]) and many impounded supplies, must eventually be filtered to meet the rapidly spreading demand for uniformly safe and potable water. We may reasonably look forward to an extension of water filtration during the next decade fully as great as the growth from 1904 to 1914.([28])

WATER DISINFECTION.

The most important single development in the art of water purification in America during the past ten years was the introduction in 1908 of water disinfection by means of calcium hypochlorite, and more recently, by liquid chlorine.

The effectiveness of calcium hypochlorite, commercially known as chloride of lime, or bleaching powder, for the steril-

ization of both sewage and water, has been known for many years, although its use for destroying bacteria in drinking water appears not to have been proposed until 1894 (by Traube).[38] The possibilities of hypochlorite for the routine disinfection of water supplies were overlooked until very recently.

There are several widely known instances of the early use of hypochlorite sterilization in Europe.[39] As an emergency measure, chloride of lime was applied at Maidstone, England, in 1897, for cleaning the water mains after a typhoid epidemic, and was temporarily used in the water supply at Lincoln, England, in 1904-05. In both these cases comparatively large quantities of bleach were used. The treatment was not considered as a routine method of purification, but for emergency use only. As early as 1903, chloride of lime was used as a disinfectant in connection with a process of chemical water purification in operation at Middelkerke, Belgium.[40] At this same time, as part of another process, peroxide of chlorine was used in connection with other chemicals in purifying the water supply of Ostend, Belgium.[40] During the few years immediately following, disinfection of water supplies by calcium hypochlorite was introduced in several cities of Europe on a limited scale.

Disinfection by Calcium Hypochlorite.

Hypochlorite disinfection for the routine purification of public water supplies first came into use in this country in 1908. The late Dr. J. L. Leal,[41] in June of that year, advised that hypochlorite be used to purify the water supply of the Jersey City Water Supply Co. at Boonton Reservoir. The plant for applying the disinfectant was designed by Messrs. Hering and Fuller[42] and put in operation on Sept. 26th, 1908, with Mr. George A. Johnson, of the same firm, in charge.[43] In the meantime, Mr. Johnson had advised that hypochlorite sterilization be used in conjunction with mechanical filtration at the new Bubbly Creek plant of the Union Stock Yards Co. at Chicago.[44] Acting on this recommendation, hypochlorite disinfection was introduced here on August 2nd, 1908.

Water disinfection as practiced at these two plants was soon demonstrated to be a success, although it met with some

opposition at first. The process attracted wide attention and was quickly recognized by engineers and sanitarians as an economical and revolutionary means of combating water-borne disease.

The use of hypochlorite disinfection followed at a great many water works plants throughout the country. The process was applied not only at plants having no other means of purifying water, but came into use also as an auxiliary means of purification to further improve the effluent of filter plants drawing upon unusually polluted sources of supply. At the present time hypochlorite is in intermittent or continual use as a water disinfectant at approximately 600 municipal water supply plants in the United States.([45]) This growth has all occurred within the past six years. The beneficial effect of some of these installations on the quality of the water supply is very strikingly shown by the corresponding reductions in the typhoid fever death rates. Table 2, giving the figures for eight representative cities, shows that the reduction has been as high as 72 per cent in some cases, but all of this reduction, as elsewhere pointed out, must not be attributed to the improvement in the water supply.

Disinfection by Liquid Chlorine.

The use of chloride of lime in water disinfection is comparatively simple, and yet is open to serious objections.([35]) The variation in the amount of available chlorine in commercial chloride of lime, further complicated by the deterioration of the hypochlorite during storage, and the difficulty of thoroughly mixing with water, makes it difficult to secure solutions of uniform strength. Added to this difficulty is the fact that the degree of pollution, and of organic content of the water to be disinfected, may change rapidly, requiring constantly varying amounts of hypochlorite to properly disinfect the water.

These difficulties connected with the use of hypochlorite have been partly overcome by the substitution of liquid chlorine for hypochlorite.([46]) The use of liquid chlorine for disinfecting water appears to have been first introduced by Major C. R. Darnall in 1910.([47]) His process was based on the direct absorption of chlorine gas by the water to be purified. Other

TABLE NO. 2.

Decline in Typhoid Fever Death Rate in Eight Cities Following the Use of Hypochlorite Disinfection of the Water Supply. ([45])

City	Began Using Hypo.	Before Using Hypo.		After Using Hypo.		Reduction in Death Rate
		Period	Death Rate*	Period	Death Rate*	
Baltimore	June, 1911	1900-10	35.2	1912-13	22.8	35%
Cleveland	Sept., 1911	1900-10	35.5	1912-13	10.0	72%
Des Moines	Dec., 1910	1905-10	22.7	1911-13	13.4	41%
Erie	March, 1911	1900-10	38.7	1912-13	13.5	65%
Evanston	Dec., 1911	1907-10	26.0	1912-13	14.5	44%
Jersey City	Sept., 1908	1900-07	18.7	1909-13	9.3	50%
Kansas City	Jan., 1911	1900-10	42.5	1911-13	20.0	53%
Omaha	May, 1910	1900-09	22.5	1911-13	11.8	47%

* Death rate per 100,000.

experimenters working with the same end in view adopted the use of the so-called absorption tower, whereby the chlorine is absorbed by a small amount of water, the latter being then introduced into the supply to be disinfected. It is this latter process which appears so far to have had the wider application.

Liquid chlorine is now used notably at Montreal, Canada, at the Niagara Falls plant of the Western New York Water Co., at Wilmington, Del.,([48]) at four filter plants at Philadelphia,([46]) including the Torresdale plant, Ridgewood Reservoir, Brooklyn, and at Wilmington, N. C., in addition to various more recent installations.

Some of the advantages of the use of liquid chlorine in place of the old hypochlorite process are that an overdose, considerably greater than necessary to sterilize the water, does not result in an objectionable taste, and that the quantity of disinfectant can be much more closely regulated than with solutions of hypochlorite, while the germicidal action is probably superior. There are other advantages due to the less space required for the liquid chlorine plant, and the freedom from objectionable taste and odor about the plant, except during accident. The use of the liquid chlorine process probably requires more skilled attendance, but through saving in labor appears not to be more expensive than the older process.

The very wide use of water disinfection, often under competent technical supervision, has contributed largely to the rapid development of the art. We are now in an excellent position to draw conclusions as to the limitations of disinfection as a means of water purification.

The great improvement brought about by disinfection in many of our municipal water supplies is remarkably shown by the diminished typhoid death rates in certain of these cities. However, it is well known by those familiar with the subject, that water disinfection even more than water filtration is dependent for safe results to a considerable degree upon human vigilance, and to be satisfactory must be in expert hands, and that even then, the process has distinct limitations as a means of water purification.([39])

The early claims made for disinfection have been remarkably well sustained by the great success of this new process,

but it is to be pointed out that disinfection is in no way a substitute for filtration where both turbidity and bacterial problems are to be met, and overcome. The proper function of water sterilization is conceded to be either as an auxiliary to filtration, or as an emergency measure to render unfiltered supplies safe. Where a supply is continually bad, the tendency is to resort to filtration, and to use disinfection as an added safeguard against disease germs.

Other Methods of Water Disinfection.

None of the other known methods of water sterilization have yet been applied in this country on a commercial and practical scale, but remain largely in the experimental stage, although in Europe the ozone process has been rather extensively used,[49] and the violet ray process has excited interest and attention both in this country and abroad.

Future of Water Disinfection.

The very remarkable development of hypochlorite water disinfection in this country, and the recent modification of the process by the introduction of liquid chlorine has put water disinfection on a sound basis. We are safe in concluding that disinfection as an auxiliary means of water purification has come to stay, even though the disinfecting agent may be changed in the future by the further perfection of processes now known or the discovery of new and better methods.

WATER WORKS PUMPING ENGINES.

The high state of development reached ten years ago in the design of reciprocating water works pumping engines[50] accounts largely for the very slight improvement made during the past decade in this general type of pump. The design of centrifugal pumping machinery was less perfected ten years ago, and it is this type that has undergone the greatest development and contributed most to the recent evolution of water works pumping practice. Recent improvements in the design of the turbine-driven and the motor-driven centrifugal pump have greatly enlarged the field of usefulness of both of these types and their ability to compete with the reciprocating pumping engine in water works service.[51, 52] In spite of this competition, the two principal types of high duty reciprocating

TABLE NO. 3.

Duty Performances of Vertical Triple Expansion Pumping Engines.

	Builder or designer	Date of test	Location of engine	Capacity in gals. per 24 hours	Piston speed in feet	Head		Steam pressure in pounds	Indicated horse power	Percentage of mechanical efficiency	Steam i. h. p. hour	B. t. u. i. h. p. minute	Duty in foot-pounds per 1,000,000 B. t. u.	Duty in foot-pounds per 1,000 lbs. steam	Percent of thermal efficiency
						Feet	Pounds								
1	Edw. P. Allis Co.	1900	St. Louis, Mo., No. 10	15,000,000	197	292	126	126	802	96.8	10.68	202	158,077,320	179,454,250	21.00
2	" " "	1900	Boston, Mass. (Chestnut Hill)	30,000,000	195	140	61	185	748	93.3	10.33	196	163,925,300	178,497,000	21.63
3	" " "	1903	St. Louis, Mo., No. 12	15,000,000	197	293	126.8	135	796	97.7	10.88	205.2	156,900,000	177,200,000	20.67
4	Allis-Chalmers	1906	Milford, N. J.	12,000,000	203.6	334.75	145.2	176.67	......	......	....	....	....	181,433,826	....
5	Holly	1909	Albany, N. Y.	12,000,000	221.4	322.21	139.8	153.56	......	......	....	....	....	182,281,000	....
6	Allis-Chalmers	1909	Nashville, Tenn.	20,000,000	239.04	385	167	......	......	......	....	....	....	184,700,000	....
7	" "	1910	Milwaukee, Wis.	12,000,000	204.2	279	121	......	618	97.1	10.82	209	151,000,000	175,400,000	20.25
8	Holly	1910	Philadelphia, Pa.	20,000,000	221.43	220.85	95.9	180.19	......	......	....	....	163,330,000	184,476,000	....
9	Camden Iron Works......	1908	Cincinnati, Ohio	30,000,000	248	140	61	151.4	811	93.1	10.72	....	154,600,000	171,700,000	19.86
10	" " "	1908	" "	30,000,000	248	140	61	148.9	806.3	93.9	9.55	....	163,000,000	*194,403,500	21.99
11	Bethlehem Steel Co.	1914	Pittsburgh, Pa. (Mission St. Sta.)	7,000,000	200.69	441.08	191.5	160.4	574.83	97.63	9.597	....	....	**201,662,445	....

* 163° superheat.

** 100° superheat.

pumping engines continue to hold first place for municipal water works high service pumping.([52, 53]) The centrifugal pump has found its application principally in low service pumping and as reserve machinery for high service work,([54]) or in installations where fuel or power is cheap.([55]) Low first cost makes this type of pump particularly suited where operation is not continuous.

For high service pumping under continuous operation, the vertical triple expansion reciprocating pumping engine is still preeminent where capacities ranging from about 10,000,000 to 30,000,000 gallons per day are applicable. This type of engine was highly developed over a decade ago, and has undergone comparatively very little further improvement during the past ten years. That the performance of this type of pump has but slightly improved since 1904 is shown by Table 3. It seems that the limit of duty performance has practically been reached at 185,000,000 foot pounds per 1000 pounds dry saturated steam. The use of superheated steam has raised the attainable duty limit to slightly above 200,000,000 ft. pounds per 1000 pounds steam, although the duties are not comparable on this basis. The introduction of superheated steam has not become general even in the larger plants, though it represents the principal recent advance made in improving the performance of this type of pump.

Among other details, it may be noted that the Reidler valve, mechanically actuated, has been growing in favor, and in Chicago pumping stations has been made standard. This type of valve permits somewhat greater engine speed, and therefore decreased weight per horse power, among other of its desirable features.

For the smaller capacities required in high service units, ranging from 2,000,000 to 10,000,000 gallons per day, the horizontal, cross-compound, crank-and-fly-wheel, condensing pumping engine, with duty ranging from 110,000,000 to 145,000,000 foot pounds per 1000 pounds of dry steam has very generally superseded the direct-acting, non-rotative pumping engines once in general use. This type of pumping engine was so far perfected prior to 1904, that but slight improvement has since been made in the efficiency. Both the vertical compound pump-

ing engine and the horizontal, direct-acting, non-rotative, triple expansion pumping engine are still in the field, but less generally used in water works service than the cross-compound, crank-and-fly-wheel pumping engine and the vertical triple.

Centrifugal pumps have been improved in efficiency to show duties up to about 90,000,000 foot pounds per 1000 pounds dry steam for low head installations, and better than 110,000,000 foot pounds per 1000 pounds dry steam against heads from 150 to 200 feet. Low first cost and small space required have enabled the turbine driven centrifugal pump to compete successfully with the high duty reciprocating engine for reserve and fire service, and for low service pumping, especially in connection with filter plants. The very limited space required by the turbo-centrifugal unit of large capacity has often been the deciding factor in its favor. This has been particularly true in increasing the pumping capacity of stations already built but too small to accommodate new reciprocating pumping units without very expensive additions.

Interesting developments have been made since 1900 in means for the withdrawal of water from tubular wells, not only for ground water but for deep well supplies. Following the first notable installation of tubular well centrifugals at Petrograd, Russia, in 1900, self-balancing centrifugals of small diameter in multiple were successfully made and tested at the Clearing Yards in Chicago in 1902,([76]) with efficiencies of about 50%. Installations at La Grange, Ill., Waterloo, Ia., and Milwaukee (Pabst's Brewery) followed, and this type of pump, while not having a wide field to fill, has proved itself useful where needed. A recent installation at Rockford, Ill., includes not only tubular deep-well centrifugal in multiple, but is augmented by series centrifugals at the surface of the ground, delivering the well water under city pressure directly into the city distribution system. Notable experience with tubular well centrifugals has been had in a number of suburbs of Chicago, at Memphis, Tenn., and Winnipeg, Canada, and elsewhere.

The gas engine has so far had only rather limited application in municipal water works pumping in this country. Several small producer gas pumping plants have been installed,([83, 84, 85]) and the Diesel and other types of internal combustion engines

for actuating pumps are in occasional use, or have been seriously considered. The Humphreys direct acting explosion pump, developed in England since 1906,([86]) has recently been introduced in America,([87]) and may come to have some application in water works practice.

ACCIDENTS TO DISTRIBUTION SYSTEMS.

One of the most important requirements in distributing water for municipal supply is to give continuous service. The past ten years have afforded notable examples of serious interruptions of service. In the larger plants these interruptions have been caused usually by breakages in the water mains. Water hammer,([56]) defective pipe,([57]) settlement or disturbance of pipe or conduits([58]) by nearby construction, by flood,([59]) by fire and by earthquake,([60]) have all had a share in these accidents. Many of the breaks have been unavoidable, but from some of them valuable lessons have been drawn.

The losses sustained, as a result of these breaks, through interference with industry,([58]) suspension of fire protection, and pollution of the water supply, have been in some instances very great. Some of the worst conflagrations of the past decade followed water pipe breaks that resulted in failure of fire protection at a critical time.([60]) The importance of avoiding such losses and increasing the factor of safety in water distribution has led, in some cases, to the provision of cisterns scattered through the distribution system where there is danger of disruption of the system from any cause. The need of having duplicate supply mains or conduits and the importance of provision for promptly isolating parts of the distribution system, by hydrants always accessible, and other precautions,([60]) is perhaps much better recognized today than formerly.

WATER CONSUMPTION.

The question of water consumption has grown to be of vital importance in many American cities. It is now quite generally rocognized that the usual very high rates prevailing in our cities result from waste, and increasing attention has been paid during the past ten years to waste prevention. Energetic waste prevention has materially reduced the consumption in some cities, and others have been able to maintain rather

enviable low rates of consumption. Notwithstanding this work very high per capita consumption continues to be typical of many American municipal water supplies.

The consumption of water in this country varies from less than 40 gallons per capita in some cities to 400 gallons in others. This wide range in rate of consumption is still more striking if we compare it with the consumption in Great Britain, where the combined domestic and trade consumption is in several cases even below 25 gallons, and the highest rate only 70 gallons per capita.([61]) Even allowing for a somewhat more liberal legitimate domestic use of water in this country, and a greater consumption for industrial uses, it is difficult to reconcile the high rates so common in this country with the low per capita consumption abroad, and the lower rates of consumption in some of our own cities. A partial explanation is found in the very considerable waste of water. This waste is principally careless use([67]) and leakage in plumbing, as well as underground leakage, but may also be due to theft.

The total waste from these causes is so great that much attention has been given during the past decade to water waste prevention. This work, especially in the larger cities, has become a very important part of water works management, and has made possible very considerable reductions in the consumption. Greater attention has been given to metering services as a means of curtailing waste,([62]) and more attention has been given to water waste surveys. Devices for measuring flow in pipes and ingenious methods of detecting leaks have been developed that make it possible, at reasonable cost, to discover and stop large leaks in the distribution system.([63])

Several very instructive water waste surveys have been made during the past few years that throw light on the enormous waste that occurs in some of our principal cities. In Chicago, where about 200 gallons per capita is delivered to the distribution system, it was concluded that 30% of the water entering the mains was wasted through underground leakage, and 20% by leakage in defective plumbing.([61, 64]) In Chicago, it is stated that only 50% of the net pumpage actually reaches the consumer.

Considerable new data have been obtained in the last few

years in cities where all consumers were metered, and where the station output is also reliably metered. In a considerable number of these cases the proportion of water metered to the consumer to the entire output has been found to be as low as 45 to 50%. The highest percentage has not exceeded 78% to a possible 90%. This is undoubtedly an interesting field for further study.

New York, by systematic surveys and waste prevention, was able, in 1912, to reduce the total water consumption 90 million gallons per day below the estimated needs for that year.([65]) This work has been energetically carried on to tide the city over the period until the new Catskill supply becomes available. The results have continued to be so satisfactory that the rate of consumption is now lower than for many years past, and the city is assured of a sufficient supply even though the expected time of completion of the Catskill project has been postponed one year. The New York water waste surveys have cost very much less than the estimated cost of the temporary additional supplies that would otherwise have been needed. At Washington, D. C.,([66]) and other cities, work of the same kind has been carried out on a less extensive scale, but with results almost as important to the cities involved.

These water waste surveys show clearly that the figures covering what is called "consumption" may, in this country, indicate even as much as twice the amount of water actually used. They point out to the water works manager a very fertile field for economies that not only save money, but virtually increase the capacity of the plant. The usual great cost of supplying water and the difficulty of meeting constantly increasing demands make waste prevention of great importance, and we may expect increasing attention to be given to this aspect of the water supply problem.

The tendency is towards increased use of metering to reduce waste. But metering is often unpopular and is still opposed by the public in some of our largest cities. Especially in those localities where there is an abundant visible supply of water, the idea has prevailed that water should be "free as air", and in these cities popular prejudice against meters continues to be particularly strong.

Many of our largest cities, including New York, Chicago, Philadelphia, Buffalo, and Pittsburgh still have very small percentages of service metered or no meters at all,([61]) and, as a rule, very high rates of consumption. But the strong tendency, in spite of this local prejudice, is towards the more general use of meters, so that we may look forward to a great extension of the practice of metering services and charging for quantity of water used instead of by flat rate or frontage, regardless of actual use.

The tendency towards the increased use of meters([61, 68]) in municipal water works service is shown by Table No. 4.

TABLE NO. 4.

Comparison of Percentage of Metered Services at Different Periods in 82 Large American Cities.*

Percent services metered	1900		1906-12†	
	No. of cities	Total population	No. of cities	Total population
100%	1	32,700	7	660,300
75-100	13	848,700	21	2,818,900
50-75	5	509,300	12	1,004,000
25-50	15	1,221,200	14	1,718,600
10-25	9	636,300	10	2,047,100
0-10	39	11,513,500‡	18	11,569,300§
Total and averages	82	14,761,700	82	19,872,200

Considerable interest has been taken during the past few years in the classification of water consumption.([88]) Figures showing the domestic and trade consumption and use for other purposes are now comparatively rare, but will, without doubt, be more plentiful in the near future when their value is more generally appreciated.

FIRE PROTECTION.

Provision for fire protection continues to be a consideration of the utmost importance in municipal water supply. The

* These cities were all over 25,000 population in 1900. ([68])

† The data in this column was obtained for various years from 1906 to 1912, inclusive, most of it being for the years 1910, 1911, or 1912. ([61])

‡ Includes New York and one other city reported as having no meters.

§ Includes New York and six other cities reported as having no meters.

severe requirements of adequate fire protection service in certain districts of our larger cities have led, during the past ten years, to the development of independent high pressure fire systems to serve those parts of the city in which the fire hazard is unusually great. These high pressure systems have their own separate pumping stations, distributing mains and hydrants, and usually a separate source of water supply, and are in addition to and entirely distinct from the ordinary water works system serving the same district and affording some degree of fire protection.

High pressure fire systems are, as a rule, designed to furnish pressures ranging from 200 to 300 pounds per square inch. Intermittent operation, large capacity, safety and reliability in service and the ability to respond almost instantly to demand are the governing features in the design of these high pressure systems. The pumping requirements are met by widely different equipment in the more important installations so far made, showing that practice has not become standardized. One high pressure fire service pumping station is equipped with crank-and-fly-wheel plunger type pumping engines,(78) but, as a rule, centrifugal pumps are used for this service, either gas driven or actuated by motors or steam turbines. The sanitary quality of water for this service is of no consequence, and the most readily available supply is used regardless of quality. The tide-water cities even use salt water when needed.

The early installations of this kind were made in 1908 and 1909. New York City(82) and Philadelphia(77) being among the first cities to make this departure. At the present time, Baltimore, San Francisco,(79) and Oakland, Cal.,(81) as well as Toronto(80) and Winnipeg, Canada, have installed high pressure fire systems. In addition to these plants, Boston, Pittsburgh, Chicago, Hartford, Conn., and other large cities have been planning works of this kind, and we may expect to see this practice extended to many of our larger cities during the next decade.

EQUITABLE RATES, VALUATION. (69, 70, 71, 72, 73)

During the decade just past, there has been a notable movement for State and National regulation of Public Utilities where water supplies have been privately owned, and in some

States, where they are municipally owned, this regulation has operated to control more thorough examination of the value of the property devoted to the public use, the proper return to be afforded it and the just and equitable apportionment of the income to be raised among the different classes of consumers. Nearly all of the States now have established Public Utility Commissions having more or less power to regulate rates, require uniform accounting, and value property devoted to the public use. A very few of these Commissions, with restricted powers, existed prior to 1907, but the great majority of them, and notably their enlarged powers, have been created since about that date. Inasmuch as these Commissions are largely new to their responsibilities and the subject of rate regulation both in the economic, financial, and legal questions raised is admittedly difficult and complicated, their proceedings are watched with interest, and the subject is now being extensively studied.

During the decade ending in 1915, the transfer of water supply utilities to municipal ownership has continued, though less rapidly than in prior years as the number of privately owned plants diminishes. Approximately fifteen million dollars in value of private utility property in water supply has become municipally owned since 1905 in the United States, and several large properties yet remaining in private hands will undoubtedly be transferred to the public control at an early day.

CONCLUSION.

Any attempt to cover the notable matters in which municipal water supply has progressed in this country during the last decade must necessarily be treated broadly. Many interesting developments of a minor character must necessarily be omitted, but it is believed that the more important developments have been described.

For the future it is apparent that more attention is to be given to the conservation of our available supplies and their protection from contamination. This movement is already well begun in the studies of the Great Lakes, the sanitary survey of the Ohio River, and the valuable and earnest work of the State Water Surveys now in progress in many States over the

country. More and more will this close watchfulness over the purity of our water-courses and water reserve prevail, if present indications are any guide.

Another tendency in the near future will undoubtedly relate to the increased curtailment of waste. This movement, already well in progress, will have yet wider attention the more its economic necessity becomes apparent, and the increasing difficulty of extending present supplies compels the attention of our municipalities.

New and revolutionary discoveries are always possible in any art, but without discussing these opportunities for betterment it is easily to be seen that we have yet a great deal to do to organize, systematize, and standardize the problem of public water supply in this country in the next few years.

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80. ''Toronto High Pressure Fire System'', C. L. Fellows, Proc. American Water Works Ass'n, 1909.

81. ''Illustrated Description of the Salt Water High Pressure Protection System Recently Put in Operation at Oakland, Cal.'', Eng. Record, July 23, 1910.

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83. "Gas Producer Pumping Plants at Manchester, Mass.", Raymond C. Allen, Jour. New Eng. Water Works Ass'n, March, 1911.

84. "Pumping Water by Producer Gas Plant", F. A. Barbour, Proc. American Water Works Ass'n, 1908.

85. "Tests and Notes on Method of Operation of a Producer Gas Pumping Plant", James R. Fitzpatrick, Proc. American Water Works Ass'n, 1909.

86. "A Unique Direct-Acting Explosion Pump", Eng. News, Vol. 62, 603, Dec. 2, 1909.

87. "The First Large American Humphrey Pump", Eng. News, Vol. 73, 155, Jan. 28, 1915.

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DISCUSSION

Mr. Gunn.

Mr. C. M. Gunn,* Mem. Am. Soc. M. E., referred to an interesting problem which had developed in Marin County. The contract requires the using of a certain minimum amount. The amount as determined by meter is below that desired. How may the additional revenue be obtained?

Mr. Freeman.

Mr. John R. Freeman,** M. Am. Soc. C. E., referring to the query by Mr. Gunn, expressed the opinion that sufficient study had not been given to the determining of meter rates. There should be a sliding scale of rates in order to increase the use of water and insure reasonable revenue. Studies made by Hazen and Stearns warrant this view. Water should be treated as any other commodity and generous use encouraged. Pacific Coast cities (Los Angeles excepted) seem to fail in this respect. Denver, Colorado, real estate men have encouraged the generous use of water to insure beautiful lawns and gardens. More generous household use, including lawns and gardens, can be encouraged by proper layout of schedule of rates, and a proper revenue insured at the same time. He believed that Marin County might well overcome its difficulty by the use of a properly proportioned price schedule.

Mr. Trask.

Mr. F. E. Trask,† M. Am. Soc. C. E., pointed out that in southern California a provision has been made regarding increasing water consumption by establishing a reduced rate after the minimum has been reached. The object of this is to increase the use of water for irrigation and for ornamental gardening purposes. In Redlands the rates have been lowered, with a resulting larger revenue.

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Mr. T. W. Ransom,* Mem. Am. Soc. M. E., pointed out that in good residential districts, with adequate water supply, say for fire protection, 200 to 300 houses are supplied by a 2-inch pipe. With this in view, are disposition pipes made too large? He suggested the need of a study of the problem of the comparative sizes of feeder and disposition pipes, having in view the most economical combination for adequate fire protection and household use. Mr. Ransom.

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Paper No. 54

MUNICIPAL WATER SUPPLY IN FRANCE, BELGIUM, ALGERIA-TUNISIA.

GENERAL REPORT OF THE SITUATION IN 1914.

By

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The second edition of the Annual Report on Water Supply for French-speaking countries, by the author of the present paper with his collaborators,[1] gives the situation on the first day of Jan., 1909, regarding water supply for cities of more than 5000 inhabitants (as well as for many other smaller localities in these countries). In the spring of 1914 on the occasion of the Exposition of Lyon I made some investigations regarding the cities (small in number) which, since 1909, have carried out important works, either of supply or purification. It thus becomes possible to give here a general view of the present situation (shown at Lyon by means of a schematic chart). It may first, however, be useful to give in résumé the rules which are usually applied in France and in Belgium regarding the supply and distribution of water. They differ slightly, especially in regard to quantities, from those commonly employed in the United States.

RULES USUALLY APPLIED IN FRANCE AND BELGIUM.

I. QUANTITY AND QUALITY NECESSARY.

The demands which must be satisfied are of two kinds: on the one hand, physiological requirements (as for drink, the preparation of food, etc.) which call for a water supply, fresh and of a constant and absolute purity [that is to say, a water

[1] A book edited by Dunod et Pinat, 49 Quai des Grands Augustins, Paris.

free from all substances harmful to health and especially from all pathogenic germs, the colon bacillus included; and if not aseptic, at least showing a number of germs generally not exceeding 100 per cubic centimeter (1600 per cubic inch)]: on the other hand, service and industrial requirements (washing, sprinkling, irrigation, sanitary uses, flushing sewers, steam boilers, general industry, etc.) which do not require necessarily a supply rigorously pure, but rather an abundant quantity and without excessive mineral matter in solution, in order to avoid serious deposits in steam boilers or an excessive consumption of soap.

The quantity of water necessary to meet the requirements of the first category, or, more briefly, potable water, may be fixed at about 50 litres (13 gallons) per day per inhabitant. The quantity of water falling in the second category, or general service water, is extremely variable from one city to another. The minimum may be fixed at 150 to 200 litres (40 to 53 gallons) per day per inhabitant and this value may rise to 250 or 300 litres or more (66 or 80 gallons) for cities with a combined sewer system, with numerous industries or large areas to be sprinkled, etc.

Two cases may present themselves.

(1) **Single distribution.** In this case, all requirements are met with a single water supply, or at least with a single distributing system (either with water from a single source or by mingling in the same system water from several sources). In this case it is clear that all the water distributed should present the qualities required for the first category. Such condition requires therefore a supply of 250 to 300 litres (66 to 80 gallons) per day per inhabitant, of fresh water, without undue mineral content, and absolutely pure at all times. This is evidently the ideal solution.

(2) **Double distribution.** In this case,—unfortunately the more frequent, especially in large cities,—a sufficient supply of pure water cannot be economically provided, and recourse is then had to a double distributing system—one for potable water, always of irreproachable purity and freshness, and the other for a general service supply. The two systems should naturally have no intercommunication. The potable water

alone should be placed at the disposal of the public, whether at public drinking fountains or for domestic and kitchen supply; the general service water, on the other hand, is supplied to hydrants for washing and sprinkling streets, for watering gardens, for sanitary uses, for laundries (briefly for whatever concerns the exterior of the house), and finally for all industrial demands.

The system of double distribution reduces the necessity of close surveillance regarding quality and the need of filtration and sterilization, properly speaking, to the relatively small quantity of water of the first category. However, the contamination of water of the second category is by no means a matter of indifference, for if it should carry germs in large number, and especially if pathogenic in character, the sprinkling of the public highways might give rise to distributed infection by way of mud and dust. It follows that, at least in certain cases, it may become necessary to purify, to a certain extent, water of the second category.

Unfortunately, a certain number of cities of the countries studied either distribute no water at all or only water of the second category; that is to say, water impure and not suited for domestic uses without previous purification. It must be considered that the municipal authorities of these cities fail in an essential duty, and that they should without delay take due measures to relieve the inhabitants of the need of providing for themselves water suited to domestic uses.

II. SOURCES OF SUPPLY.

Recourse must be had either to water which falls and runs over the surface of the ground, or to that which has penetrated into the lower strata of soil.

(1) Surface water.

(a) **Rain Water—Cisterns.** Rain water, at the moment of its fall, may be considered pure; but it often promptly becomes subject to suspicion, especially if, as is usually the case, it is collected after having run over roofs. Cistern water should therefore, in the general case, be sterilized before used for drinking.

This source plays but a small role in the water supply of

cities except in Algeria and in Tunisia, where the native houses are often provided with cisterns.

(b) **Water from brooks, streams and rivers.** This water, which has come in contact with the soil, is usually contaminated with many thousand germs per cubic inch, and among them the colon bacillus, and can only be regarded as water of the second category. It cannot therefore serve for drinking, except on condition of previous filtration or sterilization. In cases of urgency, exception may perhaps be made in the case of streams passing through uninhabited and uncultivated country, generally mountainous in character. Even then it is necessary to very carefully organize the measures required for the protection of the storage basin against contamination. In all such cases, moreover, the location is usually sufficiently near to the feeding springs to permit with advantage of carrying the intakes back to them. In any case, since it is of the highest interest that the water at the point of intake be as pure as possible, these points should be chosen with the greatest care, in order to avoid the influence of discharge from sewers, drains, industrial establishments, etc.

(c) **Water from lakes, ponds, artificial reservoirs.** Water from marshes and shallow ponds is to be avoided, and in any case should not be used without filtration. Water from deep lakes, natural or artificial, is generally of better quality, especially if it is taken far from the shores and at a considerable depth. Nevertheless, filtration or sterilization for potable uses should even here be recommended and should be omitted only in the case of lakes or reservoirs situated in mountainous and uncultivated regions, with special care at the same time regarding the protection of the surroundings of the reservoir.

(2) Underground Water.

The soil is a filter which can restore purity to the water traversing it, but an imperfect filter of which the value in each case is to be carefully recognized. This value depends primarily on the geologic nature of the strata traversed and the advice of a geologist is usually indispensable for such examination. In general, a thickness of at least 6 meters (20 feet) of sand is necessary in order to assure a good, natural filtration. In the case of thicker strata, caution must be exercised regarding

the possible existence of fissures, often large in extent, which may permit the rapid passage of the water but without the needful purification (Vauclusian springs, resurgences, etc., especially in chalk and fissured limestone formations). Experiments have, in certain cases, been undertaken to determine the path of underground water, its sources and communication with the surface, etc. Certain substances like the yeast of beer, or certain soluble or coloring substances, like fluorescine, chloride of sodium or of calcium, serve usefully in such experimental work.

(a) **Phreatic Stratum—Wells.** The stratum nearest to the surface, or phreatic stratum, is generally contaminated throughout, and in consequence shallow wells for city supply should be condemned on principle. In the open country such wells may be good if the stratum is sufficiently deep and if the surroundings of the well are suitably protected. Deep driven or Abyssinian wells are especially to be recommended in such case.

(b) **Drainage Trenches.** In certain formations, like granite, gneiss, schists, etc., there is no water bearing source other than a relatively shallow stratum lying between bedrock and surface detritus. In such cases drainage trenches are provided, usually about, or not less than 6 meters (20 feet) in depth. It is of special importance in such case that the protection of the surface drained should be most carefully organized (title acquired to a considerable extent of surface, prohibition regarding depositing of polluting matter of every description, removal of all men, animals, etc.). If this protection cannot be realized, artificial purification must be resorted to for all such drainage water.

(c) **Deep Strata, Borings, Artesian Wells, Infiltration Galleries.** Deep strata give generally a pure water; and if it does not carry too large a mineral content, the constancy of its purity, composition and temperature gives it a high value as a drinking water.

(d) **Springs.** Springs being simply the outpouring of a water bearing stratum, the water partakes naturally of the characteristics of the water of the stratum. However, in reaching the surface the water often traverses strata of moderate

depth, where it is exposed to the danger of contamination. It follows that the intakes should be carried down to considerable depths; if possible, down into undisturbed geologic strata capable of excluding all infiltration of surface water or of water foreign to the desired source of supply. If it is not practicable to secure adequate protection in this manner, it will be necessary to assure protection for the surroundings of the spring (as above, regarding drainage). If the water supplied from the stratum itself is of uncertain quality (as from a stratum too shallow in depth, or from fissured formations), it is, of course, necessary to assure suitable protection over the entire watershed feeding the springs, of which the extent should be determined by survey.

(e) **Strata of fluvial valleys: Infiltration galleries and wells.** The underground water stratum of a fluvial valley is constituted either by the water of the underground strata of the surroundings hills which flows downward into the valley, or by the river water which filters through towards the foot of the hills, or by a mixture in some variable proportion from these two sources. In the first case, the stratum does not differ sensibly from an ordinary phreatic stratum. In the second and the third, there is involved a process of natural filtration through the sand and gravel which constitute the layer separating the intake works from the water of the river. This process requires most careful supervision. It is especially necessary to choose a point in the river where the intake water will be as pure as possible and the filtering stratum should have a sufficient thickness [at least 30 metres (100 feet)]. It should be carefully protected against every source of contamination and should especially lie above the level of submersion under flood conditions. Finally frequent examination should be made of the quality of the water obtained and it would be desirable, at times when there is evidence of an undue number of germs, to pass the water through an artificial filter or at least to recommend to the inhabitants to sterilize the water before drinking.

(f) **Artificial underground water. Intermittent Filtration.** Following the process of Thiem and G. Richert, it is sometimes possible to create an artificial, or to reinforce an underground

water stratum lying below a layer of sand thick enough to assure good filtration of the water coming through from the surface. A suitable drainage channel or wells may then be arranged to receive the product.

III. PROCESSES OF PURIFICATION. FILTRATION AND STERILIZATION.

There are three processes for the filtration of water. The one most widely used is filtration through sand according to the English method; that is, by submerged filters. In order to be effective the installation should be carefully designed and operated with regular examination and control of the bacteriological conditions, in order that no filtering basin may furnish a filtrate with germ content exceeding 100 per cubic centimeter (1600 per cubic inch), or if such limit is exceeded the water from such basin may be isolated and the filtering stratum renewed.

Non-submerged sand filters as developed by M. M. Miquel and Mouchet and used by M. Baudet at Chateaudun, give also good results if well installed and operated with care. The water is distributed in the form of a shower over a layer of fine sand about 1.2 m thick (47 inches) and the rapidity is so regulated that the filtering layer does not become submerged. These filters do not require the same degree of supervision or regularity of operation as the preceding. They are especially adapted to water already clear and for small towns.

Rapid filters of the American type may also be employed and are capable of reducing by 97 or 98% the number of germs in the raw water. They render especially good service in the case of muddy water (from rivers with a large percentage of suspended matter). The use of these filters assumes the previous addition of a coagulant such as alum. The operation of such a filter must be subject to careful bacteriological control.

Sterilization is generally more expensive than filtration on a large scale. It may be carried out by means of heat (various forms of apparatus are excellent but the overall expense is excessive); or again, by chemical procedure (especially by the use of peroxide of chlorine, process Bergé and process Duyk, or by the addition of hypochlorite of lime or of soda); or again,

by ozonisation or by the use of ultra-violet rays. The process of ozonisation (after filtration if the water is not already clear) has recently been much extended in France.

No city of France or of Belgium now employs chemical methods for the sterilization of its water supply.

IV. CONDUCTION, ELEVATION, STORAGE AND DISTRIBUTION OF WATER.

Supply conduits, aqueducts of masonry or pipes of concrete (reinforced or plain) of sandstone or of cast iron, are generally closed; that is to say, they do not allow the escape of the water carried, nor the entrance of outside water. These conduits operate with either free surface flow or under pressure (pressure pipes in this case).

Mechanical means for elevating the water to give the head necessary for distribution are numerous in type (hydraulic, steam, gas, electric). Each plant should comprise at least one spare unit, in order that any one unit may be under repair without interruption to the regular service. The delivery, as a rule, is by means of a conduit without intermediate service connections and leading direct to one or more reservoirs which serve as the actual source of supply for the distribution system.

These distribution reservoirs are usually given a capacity sufficient to safeguard against accident and to this end should be able to meet all demands for one or two days. They should furthermore preserve the water from every source of contamination and admit of ready cleaning, and to this end are commonly constructed with two compartments with ready means for isolating one from the other.

Distribution systems are usually of the interconnected type. They must be completely water-tight and are constantly under pressure in order that water may be furnished for any demand throughout the entire community, at any floor of the buildings and at every hour of the day. The pipes are generally of cast iron. The conduit for any given street should, by means of valves placed at each end, permit of isolation in case of rupture. At low points discharge valves are of value for flushing or drainage.

The only rational mode of installation for the individual

service is by means of meter measurement. The measuring valve which imposes unwelcome restrictions on the consumer is now rare, while the unmetered supply, leading to a waste of water, so often incompatible with the available supply, is still quite common.

V. CONTROL OF THE QUALITY OF THE WATER. INVESTIGATION OF PROJECTS.

In all the large cities and in all the garrison cities of France, the chemical composition, and more especially the bacteriological composition (number of germs per c.c. or cubic inch and special count of the colon bacillus), are determined with frequency, either by the laboratories of the universities (the Observatory of Montsouris for Paris), or by the laboratory of the Committee on Public Hygiene, or by the Military Health Service. The results of the analyses, interpreted by specialists (according to rules of which the scope of the present report does not permit detailed mention), thus serve to indicate the sources of water which are or which may become unsuitable for public use, and to suggest, to the municipalities concerned, their replacement.

The Bureau of Hygiene of each city follows with great care the development and distribution of typhoid fever, and holds itself in close relation with the water department.

The investigation of new projects of water supply is made by the engineers and architects of the municipality. For cities, these projects must be approved by the Higher Committee of Public Health, with reference to the analyses and the report of the public geologist. Only those localities receive state aid for which the amount of the *sur* tax (le centime) is below 1000 francs ($193.00). In Belgium, the state and the province usually grant a subvention, each to the extent of one-third of the expense.

I. CONDITION OF THE CITIES OF FRANCE.

(Note—It has not been possible to base this discussion on a census later than 1906, the results of the later census of 1911 not having yet been published.)

Among the 643 communities in France having more than 5000 inhabitants each, are found as follows:

1. One hundred and thirty-five, or 21%, which have made no provision for water supply from any distant selected source,

and which must therefore depend on wells, usually in large number, with occasional use of native springs and cisterns (rare). It is only fair to say that 22 of these cities have already investigated external sources of water supply, so that within a few years we may hope that the number in this category may be reduced to 113. Furthermore, it may be noted that in this number are comprised some 30 communes of Finistère, of the Loire Inférieure and of Morbihan, of which the population is widely scattered and which are not cities in the usual sense of the word.

2. Five hundred and eight which have brought in water from one or more external sources of supply. Of this number 25 do not extend the service to individual consumers and have only public fountains or other like provision for public supply. Among the 483 cities which distribute water to dwelling houses, 322 administer the distribution as a municipal undertaking, and 161 have granted, as a concession, the business of distribution to private corporations or, rarely, to individuals. Of the 161 cities which have granted private concessions, mention should be made of the 47 cities of the Seine and of Seine-et-Oise which are served by the Cie. Générale des Eaux and of the 8 cities which are served by the Cie. de la Banlieue de Paris; so that for the remainder of France there are hardly more than a hundred cases of private concession.

Sources of Supply.

Without speaking of ordinary private wells, which are still very numerous everywhere (public wells have become rare and tend to disappear from the cities provided with a distributing system) and which are specially common in the 135 communities which have no distribution from a central source of supply, there are found 391 cities which have water from a single source only. This does not mean that there may not be, in several cases, different local sources and different pipe lines, all, however, carrying water of the same general character. Again, there are 52 cities supplied with water from double or multiple general sources, but with miscellaneous mixture in a single distribution system; and, finally, 40 which supply water from different sources in two parallel systems, one for drinking and domestic purposes, the other for washing, sprinkling, industrial

service, etc. (double distribution). Note may be made at this point that among these cities with the double distribution, one only (Saint-Nazaire) uses sea water for sprinkling, one city (Clermont-Ferrand) uses spring water for washing and sprinkling. Three cities use for the same purpose water from an artificial reservoir; one city, water from a natural pond; three cities, water from infiltration galleries or wells; and all the others, raw river water, except Roubaix and Tourcoing, which filter the water of the Lys.

Underground sources provide potable water for most of the cities; 256 having developed native springs. Of this number, one city (Nice) ozonises the water from springs, and five (Granville, Chateaudun, Pau, St. Malo and Nancy) filter their spring water through sand (Chateaudun with non-submerged filters). Again, 38 cities have recourse to drainage supplies (generally rather shallow) and among them, three (Dinard-St. Enogat, Lorient, St. Brieuc) ozonise the water. Again, 65 cities draw their supply from artesian or deep-driven wells, and 12 of these have installed intake tunnels. Again, 57 cities make use of relatively shallow wells generally near rivers (filtering wells). Filtering galleries are also provided parallel to the shore line. Among these cities, Avignon has undertaken to ozonise the water from the wells of Montclar.

Finally, 16 cities have constructed artificial reservoirs or lakes, 8 have recourse to natural lakes and ponds and 147 to rivers. Of this latter number, 80 cities filter the water through sand, using submerged filters (among them 46 of the region surrounding Paris served by the Cie. Générale des Eaux and 8 of the group in the same region served by the Cie. des Eaux de la Banlieue). One city (Argentan) uses non-submerged filters, 11 ozonise the water generally after filtration (Paris for the water of the Marne at the installation at St. Maur, Nice, and the cities of the Côte d'Azur-Villefranche, Beaulieu, St. Jean, Eze, La Turbie, Monaco, La Condamine, Monte Carlo, Cabbé-Roquebrune and Menton, Cosne, Chartres, Armentières, Chatellerault, Sotteville-lès-Rouen, Montluçon), and three others (Lavaur, Compiègne and Marseille) have approved designs for ozonisation; finally in the case of two cities (Lunéville and l'Isle-sur-Sorgues), filtration is followed by treatment with

ultra-violet light. Among the cities which make use of the water of lakes or ponds, three (Les Sables d'Olonne, St. Servan and Paramé) treat the water with ozone; while in the case of Annonay, the water from an artificial reservoir is filtered through sand. If account is taken of the cities which are supplied with a double distribution, there remain but about 24 which use only untreated river water.

Elevation of Head.

There are found 195 cities which make no use of any mechanical means for increasing the head and where gravity alone suffices. The 288 other cities must elevate the head for all or for a part of the water distributed, and to this end use is made individually or collectively of pumps or pumping engines with motive power as follows: 70 with water-pressure engines, 228 with steam engines, 25 with gas engines, 1 with liquid fuel engine, 1 with windmill, and 30 with electric motors. The total power of these various prime movers amounts to about 36,000 horse power.

Subdivision of France into Natural Regions.

The Departments are too small to admit of comparison among themselves. They must rather be grouped, according to their geographical and geological situation, in ten regions with distinctive characteristics, as follows:

1. **Region of the North.** (Aisne, Nord, Oise, Pas-de-Calais, Seine-Inférieure, and Somme; in all, 125 cities with more than 5000 inhabitants.)

This is the region of the upper Cretaceous, and as the fissured chalk is generally very permeable, the water does not remain at the surface but sinks to deep strata, often the source of artesian flow. This is then the especial region for artesian wells and for deep borings, and 32 cities of the region have recourse to this method of supply (18 in the Department du Nord and 8 in that of Pas-de-Calais), while 36 make use of springs; and it must be added that many industries also draw their water supply from deep borings. As the water from deep strata is often difficult to bring to the surface and most frequently requires mechanical means, the number of cities of the region which do not have any regular distributing system for water (47) or which use untreated river water (9) is very consider-

able. The number which can be served by a gravity system alone (8) is very small. Armentières sterilizes with ozone and Lille has developed a design for a similar installation.

2. **Region of the East.** (Ardennes, Aube, Belfort, Cher, Côte-d'Or, Doubs, Jura, Haute-Marne, Meurthe-et-Moselle, Meuse, Nièvre, Haute-Saône, Vosges, Yonne; 80 cities with more than 5000 inhabitants each.)

Aside from a corner of granite in the Vosges, this is the classical region of the secondary deposits forming the basin around Paris, from the sandstones of the Vosges to chalk, that is to say, Triassic, Jurassic and Cretaceous—deposits which present alternations more or less regular of sandstone and of limestone with impermeable marl strata between, thus giving a water bearing stratum and a line of springs at each contact. Springs are numerous and 46 cities make use of this source of supply, of which 35 are able to use a gravity system alone. There are only 5 which have recourse to artesian wells or borings, and but 2 have developed deep sources by the method of mine tunnels after the example of Brussels, Liége and Wiesbaden. Seventeen cities make use of infiltration tunnels or wells, one uses untreated river water, and 13 have no distributing system. Cosne sterilizes the water of the Loire by ozone, and Lunéville treats the water of the Meurthe filtered through sand by ultraviolet light.

3. **Paris Region.** (Eure, Eure-et-Loir, Loir-et-Cher, Loiret, Seine, Seine-et-Marne, Seine-et-Oise; 101 cities of more than 5000 inhabitants each.)

This is the Tertiary and central part of the great Paris basin. Leaving aside Paris and environs, it is found that springs (coming especially from the sands of the Soissons and Fontainebleau regions) are quite numerous (22 cities), but that quite frequently deeper waters have been sought in the Cretaceous underlying the Tertiary. Thus 17 cities have artesian wells and it may be said that in a sense this region might be considered as the northern region extended under Paris and Versailles.

Paris merits special notice. It is known that there is a double distribution, water of the second category (general service) being furnished from the Seine (by a number of pump-

ing stations) and from the Ourcq. Domestic water (first category) is provided from (1) springs carried through aqueducts from Dhuis (limestone springs of Champigny, Eocene), from Vanne (Senonian chalk), from l'Avre (Turonian chalk), from Loing and Lemain (Senonian chalk); (2) filtering plants at the sands of St. Maur (water from the Marne which is sterilized by ozone after filtration) and at Ivry (water from the Seine). The springs furnish normally 300,000 cubic meters (79,260,000 gals.) per day and the two filtering plants are able to supply a supplementary amount of 160,000 cubic meters (42,272,000 gals.) or a mean supply of water of the first category of 166 liters (43.9 gals.) per inhabitant per day. With regard to water of the second category, the supply is about 240 liters (63.4 gals.) or in all about 400 liters (105.7 gals.) per inhabitant per day. The city has under consideration an increase of the supply of potable water by drawing on the subterranean waters in the Vals de Loire between Nevers and Gien. The distribution throughout the city is in the hands of the Cie. Générale des Eaux (private company under public control), and is measured entirely by meter.

As to the surroundings of Paris, on the one hand the Cie. Générale des Eaux has grouped 137 communes (of which 46 are cities of upwards of 5000 inhabitants) in order to give them adequate supply; a part with water from the Marne and the Seine filtered through sand, and the remainder with water from the Oise which will be filtered at an early date; on the other hand, the Cie. des Eaux de la Banlieue supplies 8 cities with filtered Seine water. Finally Chartres sterilizes river water by means of ozone, after oxidation of organic matter in contact beds.

4. Region of the Northwest. (Calvados, Orne and Sarthe: 18 cities with upwards of 5000 inhabitants each.)

This is an extension in abbreviated form, of the region of the East (western border of the basin of Paris) and there are here found the same strata and sources in the Jurassic and Cretaceous formations. There are but three cities, Le Mans, Argentan, and Sablé which have recourse to river water, and this is filtered through sand.

5. Armorican Region. (Côtes du Nord, Finistère, Ille-et-

Vilaine, Loire-Inférieure, Maine-et-Loire, Manche, Mayenne, Morbihan, Vendée: 90 cities with upwards of 5000 inhabitants each.)

This is a region of granite and of primary schists. The springs are here numerous but very small and very much scattered, and in consequence serious difficulty is experienced in collecting in one place any considerable quantity of water. It thus results that 44 localities have no distributing system, though it may be noted that this number includes the 30 communes with scattered population to which reference has already been made. In many cases (15 cities) it has been necessary to have recourse to long drainage channels, while in 20 cities the supply is drawn from springs developed by the aid of rubble drains. Five cities use untreated river water and three use river water filtered through sand (Cherbourg, Nantes and Saint-Nazaire), Les Sables d'Olonne, St. Servan and Paramé ozonise water from a natural lake, while Dinard, Lorient, and St. Brieuc ozonise water drawn from drainage sources.

6. **Region of the West.** (Charente, Charente-Inférieure, Dordogne, Indre, Indre-et-Loire, Lot, Deux-Sèvres, and Vienne: 28 cities with upwards of 5000 inhabitants each.)

In this region the Jurassic and the Cretaceous dominate, the latter covered over in places with Tertiary deposits. However, the bearing strata being less extensive, springs are more rare than in the East. Thus, 10 cities only have recourse to this source of supply, 3 have drainage sources and 3 (Indre, Indre-et-Loire) have sunken artesian wells in the Cretaceous. Note may also be made of 2 infiltration galleries, of three cities which filter river water with more or less care and, finally, of three which distribute river water without filtration. Chatellerault is about to ozonise the water of the Vienne.

7. **Region of the Central Plateau.** (Allier, Cantal, Corrèze, Creuse, Loire, Haute-Loire, Puy-de-Dôme, Rhône, Saône-et-Loire, Haute-Vienne: 57 cities with upwards of 5000 inhabitants each.)

This is the region of granite and of gneiss, with intercalation of the volcanic formations of Auvergne and of Cantal. As in Brittany, the granite and the gneiss give only small and scattered springs and it is necessary to have recourse to drain-

age methods or to gather surface water in artificial reservoirs. The lava formations filter rapidly and give rise to excellent springs at their bases. Aside from 29 cities which have developed spring water supply, there are found 10 which make use of drainage sources, generally of considerable extent, and 13 which have built reservoirs and use the water without purification (of these 13 there are 10 in the department of the Loire which is indeed the classic country of these reservoirs, but little used in the remainder of France). With Lyon and 5 localities in the neighborhood, 5 other cities use infiltration galleries or wells along the borders of rivers; six cities use untreated river water, but they have double distributing systems. Montluçon is about to install an ozonising plant.

As in mountainous countries, most of the cities are served by a simple gravity system. To this, Lyon and the neighboring cities form the only exception.

8. **Region of the South.** (Ardèche, Aveyron, Gard, Hérault, Lozère: 32 cities with upwards of 5000 inhabitants each.)

This region is in close relation with the preceding on the north and west where the formations are largely of granite or schist, and with the following on the southeast, occupied by the lower Cretaceous (Urgonian) interrupted with Tertiary deposits. The center is of Jurassic formation and is the country of the Causses. The Causses and the Urgonian are the classic countries for Vauclusian springs and for resurgences.

There are here found 19 cities supplied from springs; one (Annonay) by reservoir with filtration of the water, 4 (Nîmes, Béziers, Tournon and Pézenas) by infiltration tunnels or wells, two by filtered river water and 6 by untreated river water. Lavaur is about to install an ozonising system.

9. **Region of the Southeast.** (Ain, Bouches-du-Rhône, Drôme, Isère, Var and Vaucluse, with a part of the Alpine region: Lower Alps, Higher Alps, Alps Maritimes, and Monaco, Savoy and Upper-Savoy, and, on the other hand, Corsica: 59 cities with upwards of 5000 inhabitants each.)

This region, going from the Alps to the Rhone, is occupied in its central part by the great Cretaceous deposits (principally Urgonian) intermingled and surrounded toward the east and

the south by the Jurassic. It is a country of Vauclusian springs and in any case of numerous sources of water supply. In the east and the south, in the Alps and l'Esterel, granite appears in layers. By reason of the mountainous character of the country, water is very abundant, but it comes often, and in summer only, from the melting of snow and ice. It is known that Corsica is almost entirely granitic and, in summer, water is scarce.

Three quarters of the cities (42) have developed water supply from springs and 41 have been able to make use of a simple gravity system (Nice ozonises the spring water and the cities of the Côte d'Azur treat similarly that from the canal of the Vésubie); 6 cities have installed infiltration wells or galleries in the gravel deposits of the valleys. Arles filters the water of the Rhone and 5 cities use untreated river water, but Marseille is about to install an ozonising system. Toulon has just built an artificial reservoir.

10. Region of the Southwest. (Aude, Haute-Garonne, Gers, Gironde, Landes, Lot-et-Garonne, Tarn, Tarn-et-Garonne, further the region of the Pyrénées: Ariège, Basses-Pyrénées, Hautes-Pyrénées and Pyrénées Orientales: 53 cities with upwards of 5000 inhabitants each.)

The region of the Pyrénées is formed by a core of granite and of primary schist drawn out from east to west and surrounded on the two sides with longitudinal layers of Jurassic and of Cretaceous. This region is naturally rich in springs. It is not, however, the same with the great plain of Aquitania, which extends northward of the chain and is entirely of Tertiary formation, from the Eocene on the east to the Pliocene on the west (Landes). In this vast extent water can scarcely be found in any abundance except in the gravelly subsoil of the valleys. Thus, 20 cities only (of which 12 are in the departments of the Pyrénées) are supplied from springs and 13 have recourse to infiltration wells or galleries in the gravel beds of the valleys: 9 draw their water from rivers (of which 2 only filter it through sand) and one city (Arcachon) uses water from a natural lake. Pau uses filtered spring water.

Note may be taken of the predominance of sources from chalk formations (61 cities have Senonian or Turonian chalk) and from limestone formations (67 cities have the Jurassic and

TABLE NO. I.

Principal Water Bearing Strata of France and Composition of the Waters.

		Formations Containing Water Bearing Strata	Number of Cities Provided	Number of Analyses	Total Hardness Soap Test*	Permanent Hardness Soap Test*	Average Chemical Composition†						
							Fixed Residue at 110°C	Ca O	Mg O	Na Cl	S O_3	H N O_3	Si O_2
Primary Deposits	I	Granite, gneiss, primitive rocks	49	35	° 5.8	° 4.1	101.	19.4	9.	40.1	11.8	14.2	13.6
	II	Volcanic rocks (trap, lava, basalt, etc.)	6	4	8.0	2.5	82.1	29.	26.5	10.2	7.5	traces	22.9
	III	Primary schist (Cambrian, Silurian, Devonian)	15	7	8.9	2.	153.1	32.2	13.	32.2	7.5	8.3	18.5
	IV	Devonian limestones	5	1	29.	7.	221.	138.	19.2	19.6	34.3	traces	traces
	V	Carboniferous limestones	2	‡									
Triassic	VI	Permian sandstone, Vosgian and parti-colored sandstone	7	21	5.4	2.6	40.6	25.2	5.7	3.8	3.7	0.2	5.5
	VII	Muschelkalk	3	11	27.2	7.	315.	137.	23.	10.	28.	3.	5.5
	VIII	Keuper and Dolomitic limestone (Keuperian)	3	20	38.3	20.8	469.	151.	62.	17.9	37.7	traces	traces
Liassic	IX	Rhetic sandstone Infraliasic (Sinemurian)	4	7	28.9	9.6	411.	128.	29.	13.7	36.	....	....
	X	Liassic limestone	3	17	30.	5.	388.	138.	19.2	15.	20.	....	....
Oolite	XI	Bajocian	32	73	23.5	7.4	270.	116.	8.6	14.6	16.9	....	....
	XII	Bathonian	3	32	22.6	5.6	252.	119.	8.	20.4	13.7	7.	12.6
	XIII	Corallian and Astartian	14	25	24.7	5.8	328.	127.	12.	9.8	19.	traces	traces
	XIV	Portlandian, Virgulian, and upper Jurassic	18	12	20.2	5.5	285.	93.7	16.5	20.7	19.5	6.8	8.2
Cretaceous	XV	Neocomian and Urgonian	19	15	20.3	7.9	250.	105.	7.8	37.	40.2	2.8	10.8
	XVI	Green Sands and Silicious stones	4	4	20.8	9.5	300.	107.	10.5	29.4	27.3	2.8	10.8
	XVII	Middle Cretaceous or Glauconitic (Cenomanian)	5	7	25.6	7.7	364.	111.	20.9	42.9	23.6	29.2	16.3
	XVIII	Upper Cretaceous (Turonian and Senonian)	61	62	25.9	6.5	350.	119.	12.2	37.7	19.5	15.9	16.5
Eocene	XIX	Landenian Sands and Sands of Bracheux	3	6	22.8	6.5	184.	73.5	23.4	27.	31.8	15.3	13.6
	XX	Sands of the Ypres or the Soissons region	6	3	35.6	21.5	421.	140.	24.6	27.	72.4	15.3	13.6
	XXI	Calcaire Grossier (Lutetian) and Beauchamp sands	8	3	29.8	9.6	332.	111.	36.1	25.2	25.1	7.7	19.9
Oligocene	XXII	Sands of Fontainebleau and Lacustrine Calcareous	9	12	28.3	14.4	373.	116.	28.	32.3	16.7	22.4	14.8
	XXIII	Calcareous deposits of Beauce (Aquitanian)	11	3	29.3	13.5	443.	147.	20.	36.4	34.8	10.	14.
	XXIV	Miocene and Pliocene (Molasse and shell marl)	6	7	22.3	4.3	258.	75.6	5.6	23.5	26.5	10.	14.
	XXV	Quarternary Alluvials	52	§									

† Parts per 1,000,000.
* The unit of measurement is equivalent to .6015 grains per gallon, or approximately 1 part in 96,980.
§ Extremely variable.
‡ No analysis.

19 have the Neocomian); springs from granite sources are also commonly found (49 cities).

The chemical composition of the water depends on the nature of the formations traversed. From this may be derived the average composition for the water of any stratum as indicated by the table (1). There may be thus noted very clearly the content of salts derived from the alkaline earths ($Ca\ O$ and $Mg\ O$); very feeble in the granite, in volcanic rocks, in primary schists and in the Permian and Vosgian sandstones. It is found in much larger proportion in calcareous or chalk formations and in the marles.

The average bacteriological composition can scarcely be defined and it appears to be demonstrated by numerous analyses that sandstones and fine sand strata of several yards thickness are alone capable of keeping the water bacteriologically pure. Water drawn from fissured calcareous strata and from superficial formations varies frequently in the number of germs, which is augmented, especially after rains. Finally, wells in the interior of loose agglomerations are ordinarily contaminated to a serious degree. From this results the necessity of purifying, in the same manner as for surface water, all water coming from such underground sources as are not of sufficient depth or properly protected.

Disposable Quantities.

These quantities are extremely variable from one city to another and in the same city, from one season to another, according to the flow of the springs. By totalizing the average supply available for cities which are provided with a distributing system there is found on the average a daily consumption of 188 litres (50 gallons) per inhabitant. Certain cities fall far below this mean and reach no more than perhaps 10 litres (2.64 gallons) per day per inhabitant in time of extreme drought, while the maximum, which is found in the city of Grenoble, reaches 1000 litres (264 gallons—the same as for ancient Rome).

Price of Service.

The prices for service are also extremely variable from 0.055 franc per cubic metre (4.0c per 1000 gals.) as at Grenoble up to 0.6, 0.7, and even 1 franc (44c, 51c and 73c per 1000 gals.)

in certain cities. The average is found between 0.25 and 0.30 francs per cubic metre (18c and 22c per 1000 gals.).

Expenses of Installation.

It has been found possible to determine the installation costs for 418 of the cities which have distributing systems. They amount to 999,859,500 francs ($192,972,884) including the 195,-750,000 francs ($37,779,750) expended by Louis XIV at Versailles. In approximating arbitrarily, according to the importance of the installation, the costs for the 90 other cities, we find between 50 and 60 millions of francs ($9,650,000 to $11,-580,000) or a grand total of about 1,055,000,000 francs ($203,-615,000). This figure, in proportion to the number of inhabitants served, indicates a cost of 80 francs per inhabitant, ($15.44) and for the average quantity provided, a cost of 431 francs per cubic metre per day ($315.00 per 1000 gallons per day). It is clear that the expense will vary greatly from one city to another according as the conditions are more or less favorable.

Following are the expenses made by certain large cities: Paris, 320,000,000 francs ($61,760,000); Marseille, 52,000,000 francs ($10,036,000), to which must be added 5,000,000 francs ($965,000) for filtration and ozonising; Lyon, 24,000,000 francs ($4,632,000); Bordeaux, 17,000,000 francs ($3,281,000); Toulouse, 7,500,000 francs ($1,447,500); Lille, 6,500,000 francs ($1,254,500), to which must be added about a million francs ($193,000) for ozonisation; Roubaix-Tourcoing, 14,000,000 francs ($2,702,000); Nantes, 6,000,000 francs ($1,158,000); Rennes, 5,200,000 francs ($1,003,600); St. Etienne, 22,150,000 francs ($4,274,950), including the water drawn from the Lignon; Nancy, 8,500,000 francs ($1,640,500); Reims, 3,500,000 francs ($675,500); Calais, 3,100,000 francs ($598,300); Clermont-Ferrand, 1,500,000 francs ($289,500).

II. CONDITION OF THE CITIES IN ALGERIA.

Aside from oases, Algeria contains only 38 cities with upwards of 5000 inhabitants each. All of these have made provision for water supply; however, 4 of these provide only public fountains and do not distribute to private individuals. The city of Oran has granted a concession for distribution to a private company; all the other cities own and operate the water

service. Nine cities are provided with the double distributing system, but in the case of Alger and Mustapha this does not go beyond elevating sea water for the washing of streets and the flushing of sewers. St. Denis-du-Sig provides spring water for domestic purposes and river water roughly filtered through sand for other purposes.

In the great majority of cases recourse is had to native springs (23 cities of which 2, Batna and Sidi-bel-Abbès, collect the water by quite extensive drainage systems); 5 cities are provided from artesian wells; and mention must be made of the fine project of multiple-borings in the plain of Mitidja which Alger-Mustapha is carrying out at the present time.

As for surface water, Constantine combines the water from the lakes of Djebel Ouach with that from the springs of Ain Fesguïa; Orléansville and Philippeville (the latter while waiting for the supply from a large spring source) mingle creek water with that from their springs; finally, Laghouat depends solely on water from canals (séguias) which is drawn by hand.

Only 9 cities are found with an installation of pumping machinery; they require together about 1000 h.p. Of this number, 2 make use of hydraulic prime movers, 2 of electric motors, the other of steam engines.

The water bearing strata which supply the springs and the wells pertain to Jurassic, Cretaceous, and Tertiary formations (especially in the Miocene and Pliocene). However, the coastwise district contains layers of gneiss, quartzites, phyllites, etc., giving birth to small native springs which serve as sources of supply for the cities of Bône and Philippeville. It appears that 5 cities draw their supply from calcareous Jurassic strata; 7 from Cretaceous, and 15 from Tertiary.

The water is much more strongly mineralized than in France, that of the Tertiary formations especially (chlorides and sulphates). It is also very often defective as regards bacteriological content, due either to poor filtration or often to inadequate protection of springs and aqueducts. Algeria and Tunisia are also strongly subject to typhoid fever, at least the population of European origin.

The selling price of water to private consumers is not far from 0.3 franc (rarely below 0.2 franc) per cubic meter (22c to 15c per 1000 gallons).

The quantity available for the 38 cities together, with a population of about 1,000,000 inhabitants, will average some 165,000 cubic meters per day (43,593,000 gallons), provided total inclusion is made of the 60,000 cubic meters from the springs of Bougie (15,852,000 gallons). But since a very small part of the water from these springs [less than 1000 cubic meters (264,200 gallons)] is actually utilized, it would give a more just result to omit this supply and to include only 100,000 cubic meters per day (26,420,000 gallons) corresponding to 100 litres per inhabitant per day (26.4 gallons). This figure is notably inferior to that of France; a result naturally explained by the greater difficulties in Algeria.

There remains to be considered the interesting system of water supply for the oases; Ouargla, Timmimoum, Oued Rir, and Touggourt. At the Ouargla there are, aside from 600 ordinary wells, 225 native spouting wells, and 32 artesian borings which give 40,000 cubic meters per day (10,568,000 gallons).

At Oued Rir there are not less than 600 native artesian wells and 234 French wells, giving together 492,000 cubic meters per day (130,000,000 gallons). The water of these wells is unfortunately very strongly charged with mineral salts.

III. CONDITION OF THE CITIES IN TUNISIA.

Of the 17 cities in this country which are provided with a system for the distribution of water, Tunis, Sousse, and Bizerta have turned over the concession to private companies. The expenditure in Tunis has reached about 22,500,000 francs ($4,342,500) and plans are now under consideration looking toward a further addition by way of spring water. Eleven cities have recourse to springs, 1 to artesian wells, Sousse makes use of infiltration galleries in the bed of the Merguellil and uses sea water for sprinkling and for the flushing of sewers [expenditures 7,250,000 francs ($1,399,250)]. Sfax has developed spring water supply from Sbeïtla at an expense of about 10,000,000 francs ($1,930,000). In the case of 4 cities, pumping plants have been installed.

As to the water bearing strata they are distributed approximately as in Algeria; the Jurassic and the Cretaceous dominate and give good springs in the limestone strata.

IV. CONDITION OF THE CITIES OF BELGIUM.[2]

(The following report is based on the official figures of population of Dec. 31, 1907.)

Out of 261 cities and communes with upwards of 5000 inhabitants each, there are 149 which are not provided with any system for the distribution of water; but out of this number 25 are about to receive a suitable supply either from neighboring cities or from private companies or from municipal installation. There will remain, therefore, very soon but 124 not provided and most of these are situated in the lower part of the country. Among the 112 cities provided with a distribution system at the present time, 1 does not distribute to private consumers, 13 form a part of the combination of the cities about Brussels supplied by the Compagnie Intercommunale des Eaux (water from the Bocq); 3 others, likewise in the neighborhood of Brussels, are provided with water from this city; 6, including Charleroi, are served by the Société des Eaux de l'arrondissement de Charleroi (water from the Aiseau); finally, three others (Antwerp, Louvain, Namur) have granted concessions to private companies; the remainder distribute by municipal enterprise. There are no cities provided with the double system of distribution,—if perhaps exception is made of Spa, which utilizes 400 cubic meters (105,680 gallons) per day from Lake Warfaaz for public service, and Ougrée, which makes use of well water for drinking and creek water for public service. But 15 cities mingle the water from 2 or several different sources. There are 47 cities which have developed native spring sources, 9 which pump from ordinary wells, 5 which have installed shallow drainage systems, and Dinant, Saventhem, and Jumet, which are provided by means of infiltration galleries, while Hal and Tubize are served from infiltration wells sunk along the border of a water course. But Belgium is the classic country for the development of water from deep mine galleries; thus are found no less than 33 cities provided with water supply from such galleries more or less developed, and 10 which are

[2] The part of the annual concerning Belgium has been prepared by Mr. Van Lint, inspector of water at Brussels, director of the journal "La Technique Sanitaire," which is the organ of the Association of Hygienic and Municipal Engineers of French-speaking countries.

served from artesian wells. As for surface waters, Ensival, Ypres, and Verviers with Andrimont [celebrated dam of La Gileppe which cost 5,000,000 francs ($965,000)] are the only cities drawing their supply from artificial reservoirs. Antwerp, Hasselt, and Blankenberghe use filtered river water; Ostend, which draws its water from the Bruges Canal, has undertaken successively various methods for sterilization (the last is peroxide of chlorine); finally, Bruges and three other smaller cities use river water untreated. The Compagnie Intercommunale des Eaux proposes to bring the water of the Bocq to Ghent, Bruges, Ostend, and other localities in the region of Flanders.

As for the elevation of the water, 49 cities require a gravity system only, 11 make use of pumps driven by hydraulic prime movers, 35 driven by steam engines, 6 driven by internal combustion engines, and 1 alone (Fleurus) driven by electric motor. The power required for these various installations is about 3000 h.p.

The available quantities are small. For the 112 cities provided there is found a daily supply on the average of about 90 litres (24 gallons) per inhabitant per day (one-half the figure found in France). This small supply arises in part from the serious difficulties produced by natural conditions, especially in the northwest of the country, the Flemish plain (eocene). The same as for the north of France, this region has no native springs and cities must needs seek their water supply at great depths and at large expense. Hence are found a large number of tunnels and deep wells, seeking their supply from the strata of eocene sands (vicinity of Laeken, Brussels, Ypres and Landen), or deeper, those of chalk formations, or still deeper, those of the carboniferous limestone formations. It is not the same for the part of the country in the southeast occupied by the primary schist formations of the Ardennes. Here native springs are numerous, but as in Brittany, they are often of small capacity (with the exception of Vauclusian springs from limestone formations). The scarcity of the supply is hence readily understood.

The quality in general is good, resulting from the depth of the supply and the nature of the filtering sand in the Flemish region and from the mountainous and wooded nature of the country for the region of the Ardennes.

Exact statements of cost are rarely obtainable. Mention may be made of 21,223,121 francs ($4,096,000) for Brussels and the three suburban communes which draw their water from the same source; 11,000,000 francs ($2,123,000) for the 16 other neighboring communes which draw their supply from the Bocq; Ghent, 2,200,000 francs ($424,600); Jumet, 1,732,500 francs ($334,350); Laeken, 1,300,000 francs ($250,900); Liége, 6,295,-600 francs ($1,215,000); Mons, 1,336,000 francs ($257,800); Tournai, 1,330,000 francs ($256,700); and Verviers, 13,200,000 francs ($2,547,600). If the costs are totaled for the 22 cities for which they are known, it appears that the average cost per cubic meter of water per day is 422 francs ($308.00 per 1000 gallons), and that the expenditure per inhabitant has not exceeded 45 francs ($8.69), which is notably less than in France.

We note, finally, that 78 localities are found with 2,500 to 5,000 inhabitants each and with a distribution of water; and some 507 communes with less than 2,500 inhabitants each which are likewise provided. This gives a total of 697 communes in Belgium out of 2,628 with a distribution of water. According to official statistics these are distributed among the various provinces, as indicated in the following table:

TABLE NO. II.

Names of Provinces	No. of communes having a distribution of water	Number of communes served by		Number of communes	
		Subterranean and spring water	Surface water	Served by gravity	Using pumping installation
Province of Antwerp	2	1	1	0	2
" " Brabant	45	45	....	20	25
" " Flanders (West)	6	4	3	2	5
" " Flanders (East)	6	5	1	5	1
" " Hainaut	60	60	....	36	24
" " Liége	191	182	9	178	14
" " Limbourg	9	7	2	4	5
" " Luxembourg	206	206	....	200	6
" " Namur	172	168	4	140	32
Total	697	678	20	585	114

Paper No. 55

WATER SUPPLY IN JAPAN.

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INTRODUCTION.

The object of this paper is to discuss the conditions of the water supply in the cities and towns of Japan, and to consider whether the people who are living in these centres are receiving a sufficient supply of pure and wholesome water or not. I shall also treat of the type and system of the water works and make a brief statement in comparing them with those of Europe and America. Finally it is my intention to make a rough statement about the present, the future and the characteristics of the water works in the above-mentioned communities.

The data of this paper are mostly taken from the latest figures, the 33rd Imperial Statistical Year Book, issued in December 1914 and the 22nd Engineering Year Book, issued by the Home Office in June 1914, supplemented by the latest statistical books issued by the various cities and the records of the 11th conference of the Japanese water works, held in 1914. The main object of this pamphlet is principally to present the entire conditions of the water supply of Japan, and to abbreviate details of less importance.

Before discussing the water works of Japan, I shall make a general statement concerning Japan. Japan proper consists of four islands, Honshu, Kyushu, Shikoku and Hokkaido, exclusive of Formosa, which was ceded to Japan by China immediately after the Chino-Japanese war in 1894-1895, Southern Saghalien, which was ceded by Russia after the Russo-Japan-

ese war in 1904-1905, Korea, which was annexed to Japan in 1910, and innumerable islands, which form the chain of islands from northeast to southwest.

Japan is situated between 21° 45′ and 50° 56′ N. latitude and 119° 18′ and 156° 32′ E. longitude, so the country extends from the tropical zone to the arctic. The total population is 67,000,000, while the total area covers 259,000 square miles. The average population per square mile is 260, so it may be considered as one of the most thickly populated countries in the world. The area of Japan proper is 148,000 square miles, which is 57% of the entire area, and the population is 50,000,000, which is 77% of the total population of Japan. The people who reside in Japan proper have the same language, customs, manners, history and belong to the same race, while those in the new possessions have different customs, manners and history. Hence in treating of the characteristics of Japan, I shall not include those people in the new possessions, and when I mention hereafter Japan, I really mean Japan proper, and I will only treat on the water works in this country.

In making a brief statement on Japanese history, we are proud to say that our country has existed from time immemorial, and has been governed by the same dynasty, founded by the will of God. Since the coronation of the first Mikado, Jimmu, to the present Emperor, 2575 years have passed away under one hundred and twenty-three emperors of the same dynasty. Japan is one of the oldest nations in the world and it is our highest ideal to be always governed in the future by the same dynasty.

Since the foundation of the country, there has been much vicissitude among our people, but on the whole, we have enjoyed so-called peace and not a single time has our country been brought under the control of a foreign country. Before we came into contact with the European civilization, we had had our own noble and high civilization, though we occasionally imported ideas from India and China. Japan being an island, situated at the eastern end of the eastern hemisphere, far from other countries, but well supplied with abundant food resources from her fertile land and favoured with a mild

climate, she hardly needed any communication with other countries. The relationship with Europe and America was only commenced about the middle of the last century, though her name had long been known through the work of Marco Polo, the celebrated Italian navigator. In fact, she had a little trade with Holland in the nineteenth century, but it was only a nominal trade. It was only sixty years ago that Japan was officially opened to foreign trade and communication, being much impressed by the visit of Commodore Perry of the United States of America. Since then, she has imported many ideas in science, arts and various other lines. The present civilization of Japan is, therefore, the outcome of the combination of western invention and that of Japan, which has made our present remarkable progress. The establishments of the water works in the urban communities has also been made as a result of the importation of western material civilization.

Japan has now all of the modern equipments, in her railways, telephones, schools, hospitals, local self-government and various other lines of improvements, which are needed for the building of modern Japan under our own ideas. The beautiful natural scenery of the country and good temper of the people have been the sources of admiration of foreigners who have visited this country. It is not strange, therefore, that Japan possesses the water works, which are one of the essential equipments of modern sanitation.

OUTLINE OF THE HISTORY OF WATER WORKS DEVELOPMENT IN JAPAN.

From a topographical view point, the quantity of rain is fairly large; in all parts of Japan, with the exception of Hokkaido, it reaches almost between 1000 and 2000 mm. (39 to 79 in.) per annum. From the view point of geological relation, Japan belongs to the volcanic zone, having, besides cultivated land, a large area of forests and plains, the fine feature of which is rarely found in other old countries, it being far different from the conditions in Egypt, Palestine and other countries in Central Asia where only wild deserts are seen at present. Thus deep green woods are found everywhere in the

country and vegetation is very active, greatly increasing the beauties of the scenery on one hand, while on the other clear water is always flowing in rivers and brooks and everywhere people are enjoying a heavenly gift of getting natural clear water. Accordingly no complaint of the want of water has ever been heard from among people, even from olden times. They have been getting water for drinking and other domestic use from shallow wells, springs or artesian wells, or directly from rivers and brooks. Each house has one well and water is drawn from it with manual power. From valleys or springs, water is conducted to necessary places by means of bamboo lines, which are, so to speak, natural pipes, or in some places, open conduits are constructed for several miles, so as to make the water route for supplying town people with water,—the water works system adopted in Tokyo in olden times being one example. The Japanese are particular about cleanliness; even the poorest classes of coolies will take a bath once a day. It may be said to be a peculiarity of the Japanese that they are fond of dusting, washing and bathing.

As regards the means of getting water, formerly only the surface water, as that in the shallow wells, was used; and though no great anxiety was experienced in the small centres having small population, in the cities and towns, people were subjected to great danger of being attacked by epidemic diseases, such as cholera and typhoid fever, and by fires. At the time when bacteriological knowledge, which very recently developed, was lacking, the origin of the diseases was unknown and many valuable lives were lost, as experienced in various towns and cities in England and Germany before the inauguration of the supply of filtered water. After the opening of Japan to communication with foreign countries, scientific civilization was introduced to Japan, and along with the development of knowledge on medical, hygienic, bacteriological and technical sciences, it was keenly felt that, in improving the hygienic condition of people in towns, purified and safe water should be supplied first of all. It was, therefore, concluded that a matter of the most urgent importance to Japanese, who experienced no want in their supply of water, was to improve

its quality, and it was about 1880 that the idea was decided to be realized. The plan of the water works at the city of Yokohama was then designed by Mr. H. Palmer, an English engineer at the Canton Water Works in China at the time. The work was started in 1885 and completed in 1887 and the water supply was at once inaugurated with a capacity of 1,800,000 imp. gallons per day per 100,000 population. This was, indeed, the first water works in Japan, the system adopted being the slow sand filtration system of English type. Since the construction of the water works, the citizens of Yokohama have enjoyed great happiness, their death rate having greatly decreased, and thus a good example was set of the usefulness of water works of modern design. It was about ten years after the first municipal filtration plant was constructed at Poughkeepsie, N. Y., and in view of the fact that the population of cities in the United States having water-works plants of slow sand filtration type at the time was about 35,000, it may be admitted that the Yokohama Water Works is one of the pioneers in adopting the modern system.

The first port where the steamers have to touch after ten days' voyage across the Pacific Ocean from America to Japan is the city of Yokohama, which has about 450,000 population. At present the water works of the city have undergone an extension, the work of which lasted for five years and was completed in March of this year, the author of this article being the chief engineer of the work. Since the completion of the extension, pure and wholesome water to the amount of 24,000,000 gallons per day is supplied to the citizens.

The example set up in Yokohama was immediately followed by Hakodate city, a commercial port in Hokkaido, where a plan for water works was designed at once and the supply of filtered water inaugurated in 1889. At Nagasaki, a commercial port in Kyushu and the oldest centre of foreign trade in Japan, the new water works was completed in 1891, as a result of which the sanitary conditions of the city have been greatly improved. In Osaka, a manufacturing centre and the second largest city in Japan, 3370 lives were lost in 1886 on account of cholera, and in 1890, 2097 houses were destroyed by

a conflagration. These bitter experiences caused the city to construct a water works. Mr. Palmer, an engineer of the Yokohama Water Works, designed it, and the plan was drawn up by Mr. Burton. The work was commenced in 1892 and was completed in 1895. Subsequently, with increase in population, extension works were carried out. The last extension work was completed in 1914, as a result of which 44,880,000 gallons of water per day are now supplied.

In Tokyo, the capital of Japan, the work of constructing the plant for supplying 5,560,000,000 gallons was started about the same time as the work in Osaka and was completed in 1900. The supply of water has, however, grown short and another large extension work is now being projected.

Thus the water plants were constructed in Yokohama and other cities, but up to the end of the nineteenth century the number of cities having water works was only seven. Since the beginning of the present century, the number has increased rapidly. According to the returns made on May 1st, 1914, the number of cities having over 20,000 residents where the water works had already been constructed was 26 and the number where plants were under construction 13, while in one city construction was proposed, making a total of 40. Thus the above mentioned cities will have perfect water works within the next few years.

The following table will show the increase of water works in Japan in cities of over 20,000 population:

	Completed before 1890	Completed between 1891-1900	Completed between 1901-1910	Completed between 1911-1915	Plants under construction	Plants proposed
Number of water works....	2	5	10	9	13	1
Cumulative sum	2	7	17	26	39	40

The following table shows the increasing rate of supply capacity of these water works:

	Completed before 1890. Am. gallons per day	Completed before 1900. Am. gallons per day	Completed before 1910. Am. gallons per day	Completed before 1915. Am. gallons per day
Total capacity of water works plants....	3,243,000	91,828,000	116,744,000	205,375,000
Relative ratio............	1	2.83	3.6	6.3

The latest increase is very marked; the capacity of water supply at present is 6.3 times that of thirty years ago, and when the capacity of the 14 plants to be completed within the next few years is added, the ratio will be greatly increased.

The above statistics show the result of an investigation carried out in cities in Japan having over 20,000 population. The number of towns having below 20,000 residents where the water works plants have already been constructed is 17, the number where plants are under construction, 5, and where construction is proposed, 6, making a total of 28. In Formosa, five cities have water works, and in Korea five; while in the leased territory in South Manchuria, eight plants have been established. Thus the aggregate number of water works in greater Japan reaches 86.

The above figures show only the number of cities and towns where water works have been established and our knowledge on the water works in Japan will be incomplete unless we know what percent of cities having over 20,000 population has plants, and what percent of population is receiving a sufficient supply of pure and safe water.

The following table will show the number and total population of cities having over 20,000 residents, in Japan proper:—

Population	Number of cities and towns	Total Population
20,000— 50,000	68	2,230,309
50,000—100,000	19	1,352,565
100,000—200,000	4	530,916
200,000—300,000	----	----------------
300,000—400,000	3	1,150,731
400,000—500,000	1	442,462
Over 500,000	2	3,412,726
Total	97	9,119,709

In Japan proper, as may be seen from the above figures, the number of cities having more than 20,000 residents is 97, with an aggregate population of 9,000,000, and thus it may be taken for granted that 18% of the total population are leading town life and 82% country life. Of all these 97 cities and towns, the city of Tokyo is the largest, with a population of over 2,000,000, and Osaka comes next, with over 1,000,000. As already stated, the number of cities and towns where water works have already been established is 26; where they are under construction, 13, and where the construction is proposed, 1; making a total of 40.

From the view point of the number of towns and cities, only 40% of the total have water works; but from the total figures of population, the number of residents in those places where the works have already been constructed is about 6,340,000, and in the 13 cities where the works which are being built, about 680,000, and in the places where the construction is proposed, 30,000. Thus the population in cities and towns where perfect water supply is established amounts to 70% of the total population of the 97 cities, and when the number of inhabitants in the places where the construction work will shortly be completed is added, it will make nearly 80%.

Reviewing the conditions of cities having more than 50,000 residents, the number of those cities is 29, with an aggregate population of 6,889,400. In 16 cities water works have been established, and in 6, works are now under construction, making a total of 21, with an aggregate population of about 6,350,000. Since about 92% of people in cities having more than 50,000 residents can avail themselves of the water works, it may be admitted that the greater part of comparatively large cities and towns are enjoying pure and wholesome water supply, from a sanitary standpoint. Now that strenuous effort is being made in other cities and towns to complete this important establishment, it is obvious that many new works will be erected shortly.

OWNERSHIP OF WATER WORKS.

In Japan when the question relating to the establishment of water works occurred, deliberative consideration was made

Table Showing the Population, Capacity and Date of Completion of the Municipal Water Works in Japan.

Names of cities	Population	Capacity of water works. Million gallons per day	Date of completion.
Yokohama	394,303	23,936,000	1887
Hakodate	87,875	2,884,000	1889
Nagasaki	176,480	2,692,000	1891
Osaka	1,226,647	44,880,000	1895
Hiroshima	142,763	3,740,000	1899
Tokyo	2,186,079	59,840,000	1900
Kobe	378,197	7,854,000	1900
Okayama	93,421	2,693,000	1905
Shimonoseki	58,254	1,907,000	1906
Akita	36,294	1,030,000	1907
Saseho	93,051	2,207,000	1908
Yokosuka	70,964	46,000	1908
Iwamisawa	22,349	337,000	1908
Mito	38,435	177,000	1910
Sakai	61,103	1,346,000	1910
Niigata	61,616	1,765,000	1910
Aomori	47,206	2,207,000	1910
Moji	55,682	1,765,000	1911
Otsu	42,869	117,000	1911
Kyoto	442,462	20,000,000	1912
Takasaki	45,183	1,474,000	1912
Iwamatsu	27,774	1,455,000	1912
Kofu	49,882	2,573,000	1913
Kokura	31,615	1,544,000	1913
Otaru	91,281	3,384,000	1913
Nagoya	378,231	13,522,000	1914
Total	6,340,016	205,375,000	

as to their ownership. After comparative study was made of the advisability, or otherwise, of making the undertaking one for private individuals or for public bodies, as well as study of the precedents, their practical merit and demerit, in the United States of America and other countries, the water works act was promulgated with Law No. 43 in February 1890. It was decided that the works should be undertaken by public communities, such as municipalities, towns and villages. Accordingly, not only the existing 26 principal water works but

even other small water works are under public ownership, and no plant under private ownership exists in Japan. This is really a peculiarity in Japan and no such example is found in any foreign country. The water works in Japan are, therefore, unified from the first and are entirely free from any disputes as regards their ownership and from any trouble between the supervisors and undertakers, which often occurs in cities and towns in foreign countries; nor is there any plant which has been municipalized after various negotiations between several independent private water companies, as in the case of the London water works.

In the session of the Imperial Diet in 1913, a proposal was made to the effect that as a means of spreading the use of the water works, a private franchise should be granted in cases where the work is not undertaken by the public communities. The proposal was carried at the Diet, as a result of which a partial amendment was introduced to the water works act with Law No. 15 on April 1st, 1913, and private ownership of the water works was acknowledged. But in view of the provisions relating to the purchase of the plant by the public body after the expiration of the business term, or even before that, it is quite obvious that the amendment was made based upon the policy that the principle of public ownership should always be observed and that private ownership could be admitted only in case of special necessity. Two years have elapsed since the amendment was effected, but only one private franchise has since been granted, and one is being applied for to the authorities concerned.

SOURCE OF WATER SUPPLY.

It can safely be stated that the source of water supply in Japan is entirely dependent upon surface water, the greater part being river water. Of the existing water works, there is none the source of which is an artesian well; the only example of the source being an artesian well is the water works in the city of Saga.

When classified according to the source of water, the result is as follows:

	Natural spring	Lake	River	Total
Number of water works	1	2	23	26

Of the water works whose sources are river water, nine have impounding reservoirs constructed with a dam, but in almost all other places, water is directly taken from the river. Almost all the sources of water supply in Japan are rich in comparatively pure and good natural water. Lately, however, various discussions have been made and many people have begun to study the question of the merit and demerit of using deep underground sources of water supply; in the near future some water works may be constructed which will take their supply of water from artesian wells. But the general tendency is still toward the use of surface water, as may be seen from the fact that of 13 water works which are now in course of construction, 12 depend upon surface water.

TYPE OF PURIFICATION.

The system of purification which was first introduced in Japan is an English system, or the slow sand filtration type. It is worthy of note that of the existing 26 water works, 25 belong to this type. The American system, or rapid filtration, is adopted at the plant at Kyoto only, the capacity of which is 20,000,000 gals. per day. At all the water works which are under construction or being proposed, and also at other small water works, the English system is adopted.

The principal reason for the slow sand filtration type being adopted at almost all the water works in Japan is that natural surface water in Japan is clear all the time, and it is not an exaggeration at all to state that water never grows turbid except on a few occasions during the flood seasons in summer and autumn. In this respect Japan resembles Europe more than America. In Europe and America, water, though not turbid, will often contain color caused by the existence of vegetable organic matters, or it may have odor or a high degree of hardness, but no source of water supply in Japan has such troubles.

The American type is adopted at the Kyoto water works, which has the only mechanical filter in Japan.

The source of supply for the Kyoto plant is the water from the largest lake in Japan, which is always clear and shows no appreciable turbidity. The raw water does not contain any color or odor, and from this view point, the slow sand filtration is naturally considered applicable. The mechanical filter is, however, adopted simply because the topographical condition there necessitates a large amount of expense if the slow sand filter, which requires a large area of land, is adopted, while the American system can be installed on a small area of land and is far more economical. This was also designed by the author, who was the chief engineer of the work at the time.

The water source of all the water works in Japan is not only physically clear but contains very little impurity, while bacteriologically it is nearly pure. This is really one of the characteristics of the water works in Japan.

As may be seen from the table relating to the mean number of bacteria contained in one cubic cm. of raw water (as a result of an examination in 1912) of the 22 principal existing water works, the total mean is 788 per cc., the maximum being 4349 at Wakamatsu and the minimum being 63 at Hakodate. There are only five places where the mean number reaches over 1000; of the other places, the average is below 1000, in five places it being less than 200. This will show how raw water of the water works in Japan has a high degree of purity and safety and it is quite natural that filtered water should contain but very few bacteria.

Inasmuch as water in Japan is clear and pure, as mentioned above, the purification process can achieve high efficiency by simple filtration, neither sterilization method nor any water softening process is adopted; calcium hypochlorite or liquid chlorine, which is used for sterilization in Europe and America, is never used in Japan, much less the ozone process or ultraviolet ray method. These methods are not altogether unknown, but are unnecessary in Japan. Only on one occasion, a few years ago at the Kyoto Water Works, was hypochlorite experimented with, aluminium sulphate being used for coagulation, and the report on the sterilizing efficiency of this substance

Table Showing the Number of Bacteria per c.c.m. of Raw and Filtered Water for the Principal Water Works Plants in Japan.

Names of water works	Number of bacteria in 1 c.c.m. Raw water	Filtered water
Otaru	705	83
Hakodate*	63	96
Tokyo	2,820	37
Kyoto	704	46
Osaka	2,675	25
Sakai	1,022	29
Yokohama	195	15
Kobe	143	12
Nagasaki	500	37
Niigata	157	55
Takasaki	667	14
Kofu	102	22
Otsu	620	19
Aomori	132	33
Akita	122	21
Okayama	527	27
Hiroshima	454	17
Shimonoseki	1,070	16
Wakamatsu	4,349	160
Moji	225	29
Kokura†	80	24
Mean	788	37

was presented to the Japanese Water Works Association. But as often stated already, natural water in Japan being scarcely turbid, the treatment of drinking water will, on many occasions, be limited to the matter of bacteriological purification. Accordingly, it is not difficult to conjecture that in the future, filtration will not be carried out and the supply will be used after sterilization has been made with calcium hypochlorite or liquid chlorine, so as to save the first cost and operating expenses of the water works.

As to the ozone process, it is believed to be only at some far distant date that it might be brought into practice in Japan like other sterilization processes, because in the climate of Japan there is much rain and the air is far more humid than

* Has no filter.

† Statistics of 1913.

that in European and American countries; moreover, the rain lasts for nearly a month, from June to July, every year, and this is against one of the general conditions of the ozone process, which requires dry air. Hence it might not be adopted as one of the purification systems before further improvements are effected so that it may become easily and economically applicable to water purification in the climate of Japan.

It is already plain that, river water in Japan being not very turbid in ordinary times, the object of purification can be attained with simply slow sand filtration; but in flood times, in summer and at the beginning of autumn, river water, which is always clear at other times, will temporarily grow turbid on many occasions. It being impossible to achieve the object of purification with simple sand filtration or the settling method on such an occasion, coagulation is used to accelerate subsidence at the water works which takes water directly from rivers, the coagulant used being aluminium sulphate, as used in European and American countries.

TYPE OF SUPPLY.

On large plains like those in the United States of America, the word water works is immediately associated with a pumping station, while in Japan it reminds one of reservoirs on high elevations. This is due to the fact that Japan being a mountainous country, not only do almost all the cities have elevated land on their own boundaries and suburbs, but it is not difficult to find water at an elevation not far distant from the cities.

It is therefore quite natural that the type of supply of almost all the water works in Japan is the gravity system. When the existing 26 principal water works are classified according to the type of supply, the result is as follows:

Table Showing the Type of Supply of Japanese Water Works.

	Purely gravity system	Purely pumping system	Partially pumping system	Total
Number of water works....	17	1	8	26

Thus the purely gravity supply, whereby water is sent by gravitation throughout the system, is adopted by over one half

of the existing water works. The pumping process, which sends water to the reservoir at a high elevation, or in which raw water is pumped up and then supplied by gravitation to the system, is adopted in eight cities; while the purely pumping system, whereby not only the taking in of water but the distribution of water is effected by direct pumping, is adopted only at Osaka. Within the knowledge of the author, there is no water works in Japan which has a stand pipe, water tower or water tank. This may also be stated as a characteristic of the water works in Japan.

CONSUMPTION OF WATER.

It is evident that the consumption of water depends upon climate, local custom, manner of living, etc. The rate of consumption of water from the water works in Japan is very small when compared with that in America, and rather approximates to that in European cities. The climate is generally warmer than in Europe; for instance, at Tokyo, which is situated in the centre of Japan, the mean temperature is 13.4 C, while the mean maximum is 18.4 C and the mean minimum 9.1 C. In view of the fact that the Japanese are great lovers of water and are fond of using water, it being their custom to take a bath every day, the rate of consumption ought to be great; but according to the statistics, the mean consumption is 30 Am. gallons per day per capita, and even in the mid-summer it scarcely exceeds 45 Am. gallons, which is greatly different from the consumption of water in American cities where the rate often reaches several hundred gallons. The rate of consumption, which ought to be large, is, as a matter of fact, small because the water supply is not entirely dependent upon water works of modern system, many houses having wells. Since in bathing, washing and sprinkling, well water is chiefly used, instead of that from the water works, the total consumption of water may be larger, but the amount taken through the water works taps is comparatively small. From such view point, it is proper to explain that in various cities in Japan there is a double system of water supply.

The double system appears to be valuable from an economical view point, but its weak point must not be overlooked at the

same time. Since each house has a well, people of the poorer classes, and those who lack sanitary knowledge, refrain from paying water rates of a few cents only, and do not avail themselves of the convenience of the water works and continue the use of well water. This is really inadmirable from a sanitary view point of the city as a whole. There is still another reason that well water is used; this is the temperature of the water from the water works. The temperature of well water being nearly uniform throughout the year, it naturally feels warm in winter and cold in summer. Accordingly when sanitation is disregarded, well water is naturally more agreeable than the water of the water works. In Japan, as it is usually thought, the entire consumption of water is not dependent upon water works, though it is the best and safest arrangement from a sanitary view point. Despite the existence of water works, it is not the whole but only a part of the citizens who actually use the water from the works. This is somewhat different from the conditions in European and American cities and towns.

When the population and the number of people actually consuming filtered water are tabulated, the result is as follows:

Table Showing the Population of Cities and Number of Citizens Actually Supplied with Filtered Water.

Name of municipality	Population	Actual number of people supplied with filtered water	Percentage
Tokyo	2,009,981	1,436,625	71.5
Kyoto	*507,719	79,974	15.8
Osaka	*1,388,909	1,278,851	92.0
Yokohama	455,244	315,356	69.3
Kobe	415,349	175,356	42.2
Hiroshima	155,697	122,690	78.8
Nagasaki	154,351	99,006	64.1
Okayama	96,484	45,249	46.9
Hakodate	89,648	83,849	93.6
Total	5,273,382	3,636,586	mean 69.0

Thus only 70 percent of the total population are supplied with filtered water. It is regrettable that the percentage of

* Statistics of 1913.

consumers of water from the water works is small; however, apparently there is a tendency, with the development of sanitary ideas and a change in customs, for the number of users, as well as the rate of consumption per capita, to increase.

FIRE EXTINCTION.

The water works are most valuable for sanitation, but at the same time their water, with high pressure, is very useful for fire extinction. The water works are used for fire protection in Europe and America, but their necessity is more keenly felt in Japan, because almost all houses in Japan are wooden buildings, while in the other countries they are generally of fireproof materials, such as brick, stone and concrete. The use of wooden buildings originated not only from the habits of the people, but also from the facts that wood is abundant and that the climate and temperature make the people satisfied to live in wooden houses, in which paper is used in place of glass. Foreigners often state that the Japanese are living in houses of bamboo and paper, which is not entirely unreasonable. These materials are easily combustible; therefore, should a fire occur when a strong breeze is prevailing, thousands of houses would at once be destroyed and it is not strange that a town might be destroyed to a barren field in a night. For instance, at a fire in Osaka in 1909, 11,306 houses were destroyed in a day and the damage sustained amounted to 15,000,000 yen ($7,500,000). Such being the condition, the Japanese are greatly afraid of fire, which is beyond the understanding of the people in Europe and America. The strenuous effort that is being made in various cities to construct water works is chiefly based on sanitary necessity, but it is evident, at the same time, that fire extinction constitutes an important reason. Fortunately, in consideration of the earthquakes, which are often experienced in Japan, the houses seldom exceed three stories in height, and as there exist no buildings shooting to the sky as in American cities, the water pressure of 50 pounds per square inch is strong enough to extinguish flames on almost all buildings. In all the towns and cities where water works are installed many fire hydrants are provided in the streets.

THE COST OF CONSTRUCTION.

In Japan the water works plants can be constructed at a very small expense, when compared with European and American cities and towns. It is due to the fact that in Japan the individual consumption is small and can be fully met by the water works on a scale of one fourth or one fifth of that in a town in the United States where the population is nearly the same. Moreover, the price of commodities is comparatively low, while the costs of land and labour are far smaller than in European and American countries. The construction materials of water works, such as cast iron pipes, valves, cement, stone, sand, gravel, machines, etc., are abundantly produced in the country, and there is almost no necessity of importing even lead pipes and water meters to be used for house fittings, except only special articles which are not largely produced in Japan. It is regrettable that the cost of cast iron pipe is higher by between 20 and 40 percent than in Europe and America; but with the development of industry in the future, iron pipes will be produced more cheaply and the construction expenses be greatly curtailed.

The total construction expense of the existing twenty-six water works is 58,978,371 yen ($29,489,185). When the amount is divided by the total capacity of 206 million gallons, as well as by the expected number of consumers, it comes to 287,700 yen ($143,850) per million gallons and 16 yen ($8) per capita respectively.

The following table shows the result of investigations relating to the construction cost of a few typical filters of the existing water works and may be helpful for the comparison between the construction cost in Japan and America.

Table Showing the Cost of Construction of Filters.

Name of Plants.	Total Cost of Filters, Yen.	Daily Capacity Am. Gallons Per Day.	Cost of Filter per Million Gallon, Yen.
Yokohama	566,822	23,936,000	23,806 ($11,903)
Osaka	958,761	44,880,000	21,363 ($10,681)
Nagoya	395,883	13,502,000	29,277 ($14,638)
Otaru	114,473	3,384,000	33,827 ($16,913)
Mean			27,068 ($13,534)

Thus it is shown that 27,068 yen ($13,534) is required for a filtration capacity of one million gallons per day, on an average. According to the returns of construction expenses for the principal slow sand filters in America, published by Mr. G. A. Johnson in the Journal of the American Water Works Association, $32,600 is required for a capacity of one million gallons per day, on an average. Since 27,068 yen corresponds to $13,000, the average construction expense in Japan is only about 40 percent of the construction cost of similar filters in America. The reason the work can be done so cheaply is partly because the costs of materials are low and partly because, as the climate in Japan is warm, most of the slow sand filters, with the exception of those at one or two plants in the northern districts, are left uncovered. In America, however, they are entirely covered, on account of the cold climate.

As regards the construction cost of mechanical filter plants, no full comparison can be made, as the system is not adopted in any place in Japan except at the municipal plant in Kyoto. The capacity of the Kyoto water works is 20,000,000 gallons per day and the construction cost of the mechanical filter was 474,121 yen ($237,060) in all, or 23,706 yen ($11,853) per million gallons. According to investigations carried out by Mr. G. A. Johnson, the construction cost of a mechanical filter plant in America is $12,100 per million gallons on an average. Thus the construction cost of the Kyoto plant is nearly the same.

The filtration system adopted at the Kyoto Water Works is the Jewell filter, one of the American patents. Inasmuch as the plant was imported from America, the cost ought to be large, but in fact, it is rather cheaper than in America, or practically equal.

Thus it may be seen from the above figures that the cost of construction per million gallons in Japan is nearly equal, either by the mechanical filter or slow sand filter. The cost of the mechanical filter in Kyoto is 23,706 yen per million gallons and that of the slow sand filter in Yokohama is 23,806 yen; both being typical cases of recent construction, it is amply proved that the cost of constructing either of them is nearly

the same. In America, the mechanical filter is used more than the slow sand filter, as most of the raw water there is turbid, and also the construction cost is far cheaper than that of the slow sand filter. In Japan, the natural water is generally clear, and any type of filter can be established with nearly the same cost. Accordingly, the slow sand filter is chiefly adopted, the mechanical filter plant being established at the Kyoto plant only. In view of such a state of affairs, there can be no doubt that the slow sand filter will be the one chiefly used in the future.

TAPPING.

In the management of water works, a point somewhat different from any arising in European and American countries is a portion of the regulations relating to the supply of water. In Europe and America the unit of the organization of society is a private individual, but in Japan it is a house, or family, the difference originating in the custom and history since the foundation of the country. In Japan, from the upper and middle classes down to the lowest classes, people attach great importance to their respective residences. Each family lives in an independent house and has its own garden, even if small. The number of people in one family is five, on an average. A building which has many stories and where many families, with hundreds of people, are living under one roof can never be seen in Japan. Accordingly, nearly the exact population may be obtained if the number of houses is multiplied by five. In the regulations relating to the supply of water, it is considered convenient to make a house instead of a tap the unit, and the supply of water is regulated based on this policy. No meter is attached to the tap exclusively used by a family, and a fixed charge is collected monthly or yearly in case the family does not consist of more than five persons. A meter is attached to the tap and the water rate is collected according to measure at schools, hospital offices, mills and other houses where many people are assembled. Though the policy is modified more or less according to the condition of the towns and cities or by other circumstances, the above policy is adopted at twenty-five places, Osaka being the only city entirely metered.

A common fountain is established in the streets or compounds for the people in the lower classes who are not rich enough to have a tap installed for their exclusive use, and is allotted for the common use of many families. A small water tax is collected for the common fountain.

WATER WORKS OF FORMOSA, KOREA, AND SOUTH MANCHURIA.

Now that I have described in outline the municipal water works in Japan proper, I think it is not altogether out of place to say a few words about the water works in Formosa, Korea, and South Manchuria.

Water works in Formosa:—Twenty years have elapsed since the island came into the possession of Japan after the Chino-Japanese war. Water works are now established at five principal cities of the island, namely, Keelung, Tamsui, Shoka, Taipeh and Takao. One of the plants takes spring water and the other three, directly or indirectly, take river water. The pumping system is adopted by two, and the entirely gravity supply by the others. The purification system is the slow sand filtration type, as in Japan proper, and the total capacity is about 7,000,000 Am. gallons per day. All the plants are under the control of the Formosan Government General.

Water works in Korea:—After the conclusion of the Russo-Japanese war, Korea was made a protectorate of Japan, but five years ago she was annexed to Japan. The water works in important cities were projected when the country was still the protectorate of Japan, and at present plants have been completed in the five cities, Seoul, Chemulpo, Fusan, Pingyangan and Mokpo. Their sources are river water. The entirely gravity system is adopted at two plants and the pumping system at three others. The purification system is of the slow sand filtration type and the total capacity is about 10,000,000 gallons. The plants are under the control of the Government General of Chosen.

Water works in South Manchuria:—The principal towns in the leased territory of Japan in South Manchuria are Port Arthur and Dairen. The water works there were constructed when the ports were under the rule of Russia. The source of

the water supply of the plants is underground water and the total capacity is about 3,000,000 gallons per day. The plants are under the Kwantung Government General.

Besides the above, there are six water works undertaken by the South Manchuria Railway Company in the district along the railway line. The water source is raw water of wells constructed on river banks, and the total capacity is 2,000,000 gallons per day. The pumping system is adopted at all the plants.

CONCLUSION.

On the whole, perfect water supply is established at most of the important cities and towns and is expected to be greatly increased within the next few years. I can safely declare that the Japanese Government and people, either at home or in the colonies, are making strenuous efforts not only to increase their water supplies, but also to improve the accommodation so as to place it in an up-to-date condition. Any foreigner can travel or reside in Japan at ease, so far as pure water is concerned.

In conclusion, the author will be much pleased if the above brief description impresses the reader with a general idea of the water question of Japan. As regards further details, I am confident that the municipalities concerned will be willing to give any necessary information, if requested.

Paper No. 56

THE DISPOSAL OF SUSPENDED MATTER IN SEWAGE.

By

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Since the first World's Fair held in London 1856, the centers of population of all civilized countries have grown to such proportions and so rapidly that many new problems concerning city works and their management have presented themselves for solution.

Among the more important of these problems are those which comprise the collection and proper disposal of the great variety and mass of refuse materials, the removal and treatment of which in large communities often present a formidable task.

This task is not alone a financial one relating to the economical collection, removal and treatment. It is also a sanitary one, in order to prevent any injury to health and all nuisances incidentally liable to occur. Health may be injured by the spread of disease germs which get into the refuse from sick persons and animals; and various nuisances may be created by a delayed removal, causing chemical changes which create offensive products.

Since such undesirable results have arisen, efforts have been made to obviate them, sometimes successfully, when the conditions were simple and the bulk was small, and sometimes unsuccessfully, when the conditions were complex and involved.

It is less than a decade since we have been able to say that it is not only possible but economically practicable to collect all city refuse, solid and liquid, at the sources for delivery at suitable points, and to finally dispose of its parts so that nowhere along the line either a serious danger to health or a nuisance need exist.

The present paper is limited to a discussion of the treatment of the liquid refuse of a city, usually called sewage, the subject of removing solid refuse having been fully discussed at the International Congress on Hygiene and Demography, held in Washington in 1912. It is further limited to the brief assembly of the essential principles which govern the design and operation of sewerage works, with special reference to securing healthful results and preventing nuisances from the suspended matter contained therein.

Sewage is the dirty waste water rejected by a community and serving as a carrier of light solid matter in suspension which is discharged from water-closets, bath tubs, wash bowls, sinks, etc. It contains, roughly, 1 part of organic matter and 1 part of mineral matter carried by between 1,000 and 5,000 parts of water, this difference indicating the variation in different cities.

The organic matter, which alone concerns the question of health and nuisance, differs materially in quality. Some of it is unstable, breaks down quickly and may putrefy within a day, such as certain animal and vegetable liquids; and some is stable and decomposes very slowly, such as hair, wood fiber, epidermis, cartilage and the like.

The unstable matter causes all the nuisance arising from sewage, as it has but a slight resistance to decomposition. It first absorbs oxygen with avidity to form more stable compounds; these have no offensive odor of themselves nor do they produce gases with foul odors. When the conditions have become such that oxygen for absorption is no longer available in the medium holding the unstable matter, other chemical processes become active, producing chiefly hydrogen compounds. Among the latter we have those which produce foul smelling gases and others which do not.

The dangers to health lie in the transportation to other points of pathogenic bacteria contained in the fresh sewage from sick persons and in the subsequent possibility of their once more getting into the bodies of human beings and higher animals. Bacteria not only adhere to particles of solid matter but, unless disturbed, remain in any liquid carrying them. It is possible that solid particles of sewage may be stranded in

sewers, be held back and finally be blown away by an air current, enter the atmosphere and thus, by contact, cause a new infection. It is also possible that liquids may splash and throw bacteria into the air. In both cases the danger of transmitting disease is extremely small if the sewers have smooth interior surfaces, no opportunities for eddies to form, and good grades to cause a rapid velocity from the sewage receptacles to the outfall. These conditions have been advocated for many years and are the same which will also prevent nuisances.

SANITARY COLLECTION AND DELIVERY OF SEWAGE.

Our wash and bath rooms, toilets, kitchens, laundries, etc., are now supplied with fixtures in such a manner that offensiveness can be entirely excluded. This is done simply by giving them forms and surfaces upon which the dirty water can flow away quickly, no solid particles remain on the surfaces and a final flushing with clean water will restore the receptacles to their condition before use.

The pipes carrying into the sewers the sewage thus generated should, likewise, carry it away quickly and completely. The necessary means for accomplishing this are first, smooth and evenly curved and jointed pipes, and second, good currents of air circulation. The former prevents the catching, retention and consequent putrefaction of solid particles, the latter tends to clean up the exposed surfaces which are otherwise usually covered with slimy growths. This air circulation is automatically established by providing openings to the sewer from the street surfaces, and openings to the house pipes above the roofs of buildings. The air currents are produced by differences of temperature within the sewers, on the street surfaces and above the roofs of buildings, and also by sudden discharges of large quantities of water down the house pipes. It will readily be seen that the currents cannot always be in the same direction. When the outside air is colder, the current must be upwards, and vice versa. The reversal of air flow through the house pipes is not objectionable if the sewage is not putrescent, no foul deposits are in the pipes and the ventilation is free and ample.

It was formerly strongly opposed, particularly in England, to have street sewer air pass up through the house pipes to the

roof. It was feared that street sewer air might enter rooms through imperfect pipes or through the fixtures if their traps were not in order. This opposition is still frequently maintained. On the European Continent and in many American cities, the ventilation of street sewers through house pipes has, however, been found very advantageous and the practice is growing. The house pipes are kept much cleaner, the slimy coating is largely removed and the escaping air above the roofs is less odorous than when the house pipes are trapped at the bottom against the street sewer. A careful examination made in this country proved that the escaping air from house pipes contains practically no disease germs or other bacteria and has no offensive odor if the ventilation is good.

After the house sewage enters the street sewers it should be kept flowing without any interruption. This result is readily gotten if the sewers are properly designed and built. The surfaces should be smooth. Vitrified clay pipes, used for small sewers more than any other kind in this country, have the smoothest surfaces. Brick sewers furnish a rough surface even if the joints are carefully made and the bricks are of the best. With good flushing and brushing down at proper intervals they may, however, be kept in a condition, so as to entirely prevent offensive odors from the suspended sewage matter therein and disease germs from being retained in a virile condition.

Flushing is another important requirement to prevent offensive odors from the suspended matters in sewage. Above ground, within our houses and on our bodies, we use ample amounts of water for cleansing purposes. Below ground in sewers, ample flushing is equally, and even more, necessary, due to the relatively greater concentration of unstable decomposing suspended matter. Unfortunately, in our country the flushing of sewers has not been given as much attention as is desirable. In almost all European countries, both small and large sewers are flushed frequently, varying from several times a week to once in one or two months. The results of this frequent flushing are very satisfactory and the money is willingly appropriated.

In our country, particularly in smaller cities, we have extensively introduced automatic flush tanks at the heads of

all pipe sewers. While these tanks keep the upper ends of the sewers clean and free from deposited suspended matter in a very satisfactory manner, they do not keep the larger sewers lower down the line free from deposits and odors. In this respect our sewer systems could be greatly improved and the odors therefrom materially diminished by introducing flushing arrangements.

When collecting sewers are very long and the distance to the outfall is great, which fact is generally associated with flat grades and slow velocities, we have almost always some putrefaction and offensive odors arising near the lower end. During the long run the oxygen has become exhausted and hydrogen compounds, notably sulphureted hydrogen, are developed. This condition may be improved by emphasizing several remedies above mentioned. Still another expedient is practicable, by replenishing, through artificial aeration, the dissolved air, from which the oxygen has been exhausted and putrefaction has been initiated. Experiments have been made recently, both in England and in America, to accomplish this purpose and have resulted in more or less success. Where it is possible to force air into a sewage pumping main, under a pressure of at least one atmosphere, good results have been obtained. The air is distributed throughout the water mass, evidenced by the fact that when the pressure is released, the excessive air causes a sewage of milk-like appearance from which the air bubbles soon disappear. If sewage bacteria are present in sufficient quantities, an accelerated oxidation of the dissolved organic matter takes place, and the distance of flow before putrefaction begins is lengthened.

Distributing air into the sewage within the flowing section under ordinary pressures seems as yet to have given only moderately good results.

There is still another method available by which sewage oxidation can be facilitated and putrefaction retarded, should the sewage have to flow a long distance to works for treatment. Incidentally, the expense of the final treatment would also be reduced thereby.

When we consider that but very little of the organic matter which is discharged into sewers at the house is dissolved,

and that about one half of it is dissolved when the sewage reaches the outfall of an average city, and also, that dissolved matter withdraws oxygen from the water more quickly than the suspended matter, we must conclude that a removal of the suspended matter by fine screening higher up the sewer, before much is dissolved, should be of benefit. Fine screens near the beginning of the main sewers might, for instance, not only prevent foul odors from the sewage near the lower districts, but prevent also the necessity and expense of works for oxidizing the amount of dissolved organic matter which is thus eliminated. Whether or not this expedient will be economical must be determined in each case.

The means for removing suspended matter from sewage are settling basins and fine screens. Settling basins require space in which the flowing sewage can be brought to almost a standstill, and give sufficient time for the suspended matter to drop to the bottom of the basin. Unless this matter reaches a second basin for separate decomposition (see below under "Imhoff Tank") it must be frequently removed, which in the upper parts of a city's sewerage system would generally be objectionable. The superiority of settling basins over screens lies chiefly in facilitating the deposit of the finer and water-saturated parts of the organic matter, which screens generally allow to pass on, and which is a condition in the lower parts of a city's system. The particles of suspended matter have their largest size near the sewage origin, and more particles may, therefore, be caught by a screen before a run in the sewer has begun to break them up. Most of this unbroken matter is lighter than water. It first floats and settles, if at all, after it is thoroughly water-logged. Therefore, it would appear that fine screens can be more effective in removing suspended matter near where main sewers begin than where they discharge, and that settling basins can be more effective near the latter points.

The above discussion has covered the general principles concerning suspended matter which should be considered when collecting sewage from an inhabited district, if a complete and rapid delivery to the outfall is to be secured under conditions which are both economical and non-odorous. We have now to

mention the general principles which must be considered when finally disposing of the sewage.

SANITARY DISPOSAL OF SEWAGE.

Greater nuisances have been caused by improper sewage disposal than in the collecting system.

It was stated at the outset that we must place the sewage under such conditions that its decomposition will be facilitated by contact with oxygen, and in the absence of oxygen, by such combinations of hydrogen as will produce no offensive odors.

All processes of sewage treatment and disposal, if they are to be satisfactory, permanent and economical, should require, first, a separation from each other of the floating matter, of the settling matter and of the liquids.

As these three parts of the sewage are materially different, one being solid and light, one solid and heavy and one liquid, the methods of economical treatment, in order to make them inoffensive, will also be different in nearly all cases and, therefore, a separation is generally to be recommended. As yet it is not always made, and at some places it may not yet be of sufficient importance to justify the additional expenditure. The drift of opinion, however, is clearly in the direction of separation and we should endeavor to design our works accordingly.

The floating matter can be retained with little trouble and expense, either by screens or on the surface of settling tanks. Being often offensive, its best final disposition is usually by fire or by burial.

The settling matter, which forms the so-called sludge, is that part of the sewage which has always given the greatest amount of trouble. It has constituted the greatest nuisance and, until within only a few years ago, has successfully defied a treatment which would everywhere allow of its inoffensive disposal.

The bulk of the sludge does not naturally decompose by oxidation. Its exposure to the atmosphere allows but a thin film to oxidize at the surface, but the exposure permits it to take up many species of bacteria, some of which cause offensive putrefaction. Many ways and means have been tried for the last fifty years, both in England and Germany, to get inoffens-

ive sludge decomposition. A solution was at last found in an expedient which allows the sludge to decompose under water with the exclusion, practically, of all fresh sewage and air.

The first step towards getting this result was taken by Dr. W. O. Travis of Hampton, England, who devised a two-story tank, the upper division serving as a settling tank with a slot at the lower edge of an inclined bottom, through which the settling suspended matter passed into the lower division to accumulate and decompose. The in- and out-flows of the two tanks were so proportioned that from three fifths to four fifths of the sewage passed through the upper division and one fifth to two fifths through the lower one. The largest Travis tank is in Norwich, England. So far as an inoffensive sludge decomposition is concerned, the Travis tank is not a success.

The same two-story tank was later built in the Emscher district of Germany, by Dr. Ing. K. Imhoff, with at least one important change. No sewage whatever was allowed to pass through the lower tank, thus preventing any part of the sludge from having a continuous contact with fresh sewage and air. Also other advantageous changes were made in this new tank.

The decomposition of the sludge takes place in the lower division and in the absence of dissolved oxygen, but the novel condition is that it continues in the absence, also, of sulphur bacteria producing sulphureted hydrogen, and in the presence of bacteria producing substantially only methane and carbon dioxide gases, both of which have no offensive odor. The conditions in the tank gradually become adjusted to conditions favoring the life of substantially only these two classes of bacteria and causing practically all of the others to become inactive.

Quite a varied experience has already been gained with this Imhoff method of disposing of the settling suspended matter of sewage. It has been applied to dilute and strong sewages, to domestic and different trade sewages, and it has so far been found satisfactory in all cases where the conditions for the required special bacterial life were favorable.

We are now facing suggestions for some further variations and improvements of the method. Both in Germany and in the United States, thorough investigations of such suggestions have been and are still being made.

It is naturally found that the details of the process may differ with the character of the sewage. The same design and the proportions of its parts may vary under different conditions. The topography of the site alone may determine quite different designs. For instance, we may find in one locality a deep double-deck Imhoff tank to be preferable, while in another two shallow single-deck tanks side by side may be more economical.

The first has the advantage of an automatic sludge separation. Its greater depth has the further advantage of placing the gases of decomposition under greater pressure which, when the sludge is finally withdrawn and discharged on the surface of the ground, causes the gases to expand and to make the sludge more porous and, therefore, more readily drained and dried than where the gases form under shallower depths. The double-deck tank has, however, the disadvantage of greater depth of excavation, perhaps in rock or in wet soil, and also the necessity of getting the right proportion of capacity between upper and lower tanks. If the proportion does not approximately correspond to that of the suspended and liquid matter, the efficiency and economical results may not be quite satisfactory. The shallower single-deck tanks have been studied in Berlin and in the United States, particularly by Mr. E. J. Fort, Chief Engineer, Bureau of Sewers, Borough of Brooklyn. It has been found that the suspended matter is decomposed in the same inoffensive manner as in the deep tanks. The gases of decomposition are also chiefly methane and carbon dioxide, and after final withdrawal, the sludge has also no offensive odor. There is, further, the advantage of complete independence of the two tanks, so that any irregularities in the sludge tank can never have a detrimental influence upon the sewage discharging in the settling tank, and the further advantage, that extensions can be more readily made and that an inspection of every part is easier than in the double-deck tank. On the other hand, the disadvantages are that the shallower depth causes the sludge to be less porous and less easily drainable, and that it must be pumped or otherwise specially conveyed from the gutter in the settling tank to the adjoining sludge tank. The separate sludge tanks can be built as single units and can be intermit-

tently filled, or they can be built as a series of tanks continuously operated.

Where separate sludge tanks have been continuously exposed to the air, as in Baltimore and Worchester, inoffensive sludge, such as comes from the Imhoff tanks, has not been obtained. The reason appears to be the long exposure of the sludge to the air. In the experiment station of the City of Brooklyn these tanks have been kept covered and the atmospheric air has been substantially excluded. The result has been a sludge as completely inoffensive as that obtained from the Imhoff tanks. It therefore seems desirable to cover such separate sludge tanks, to prevent the free access of bacteria from the air, and the space under the cover should be filled with the resulting gases of decomposition rising from the sludge. But, these gases, when excessive, must be allowed naturally to escape through proper sized openings, and the free inflow of atmospheric air can also be readily prevented.

The preference between the two methods, having the two tanks over or beside each other, may usually be decided on the relative economy of construction and operation, and on the desired quality of the sludge.

In the process of ripening, the sludge has a grayish color. When ripe it has become black and has a peculiar tar-like though not disagreeable odor. It has also lost its original slimy and sticky consistency and has become porous and friable, allowing its water, which is clear, odorless and quite inoffensive, at once to be discharged into streams. The sludge of the shallower tanks is less porous and less easily and quickly drained.

The sludge generally reacts alkaline. Berlin reports that when left in the tanks too long it may again change to a grayish color, having a distinct acid reaction and offensive odor, and it no longer drains easily. How this change is brought about is not reported, and it has not been noticed at some of the stations in the United States.

In order that the sludge may decompose satisfactorily and quickly, it must not be acid. The acidity can be generally produced, if not from manufacturing waste, from an excessive vegetable diet of a community. When it appears and interferes

with the normal decomposition, the sludge may be brought into intimate contact with a moderate amount of fresh sewage, which is usually alkaline, although the amount of such sewage should not be enough to disturb the required bacterial flora already established in the sludge. It is generally better to add some clean hard water or some alkaline solutions.

Perhaps nowhere else than at the Berlin Experiment Station has the desirability of getting a good alkaline sludge been better demonstrated. It can commonly be obtained by a frequent stirring, so that fresh parts will be frequently exposed to bacterial action and the toxines removed. The stirring is best done by mechanical agitators. They should be used daily or more or less often as may be found best, according to the varying character of the newly deposited suspended matter. Comparative experiments with mechanical agitators and with compressed air bubbles forced in at the bottom of the sludge and rising through it have so far indicated a greater efficiency for the former.

As to the character of sludge withdrawals, experiments have indicated that the best results follow when the withdrawals are regular, frequent and in small amounts at a time.

Where sludge is spread upon beds for drying, the climate must be sufficiently temperate to prevent its long remaining frozen. Where the drying beds cannot be covered to moderate the winter temperature, it is better to increase the size of the sludge tanks, so that winter storage can be provided in them. This excessive storage does not so far seem to have been objectionable in this country. To keep the sludge in a good alkaline condition it is, however, well to agitate the older as well as the fresher sludge.

The usual variations in the composition and temperature of the sewage necessarily produce irregularities in the behavior of the suspended matter; much of it may not readily settle into the sludge tank, or the lighter materials when released may rise up from it. Occasionally, therefore, we see excessive frothing or scum formation. When these amounts become quite large they require radical means for treatment. Small amounts can be scooped up at the surface and burned or buried. Large amounts require other methods of removal.

As a permanent practice it is not economical nor very efficient to break up the scum by hand with poles or with a stream of water, which causes much of it again to settle into the sludge tank. Agitation by mechanical means has been found more useful to settle the frothing and the scum.

Experience has gradually indicated the extent of area which should be provided in the chimneys through which the light particles of suspended matter rise from the sludge tank to the surface. If they are made too small, they tend to cause the scum to rise up high and to flow over. If they are too large, they may, by a large exposure to the air, invite development of putrefactive bacteria and, therefore, the formation of a nuisance.

When much frothing is found on the surface of the tank, experiments have indicated that this objectionable condition may be removed also by draining or pumping out the sewage as far down into the sludge tank as practicable, and by refilling the space with clean water from the municipal supply; especially, if this is hard water and contains carbonate of lime. The frothing may also be reduced by adding to the sewage slight quantities of lime or soda before it enters the tank, especially, if the alkalinity of the sewage is very low.

Cases are now multiplying where some injury may be done both to the process of sludge decomposition, as well as to the otherwise odorless sewage treatment, by the admission to the sewers of gasoline, due to its growing use for automobiles, etc. This admission not only gives an objectionable odor at the sewage treatment works, not distinguished by most people from the odor of sewage, but it also reduces, and this is more important, the rate of bacterial activity in the sewage and sludge and, therefore, the desired rapid decomposition. Legal means may keep the injury from becoming serious.

The automatic sludge decomposition in separate tanks, as just described, should not entirely rule out the old method of precipitating the suspended matter by an added coagulating material, such as lime and the sulphates of alumina and iron, which method has been used for over 50 years. The precipitating processes are not always excessively expensive, and, in some cases, may actually be most economical in the removal of

suspended matter. This may be particularly the case when only a clarification of the sewage is required and where plain settling, such as takes place in the upper chamber of the Imhoff tanks, is insufficient and, also, where such clarified sewage can be turned, without objection, into a sufficiently large water course.

There has recently been brought into more or less prominence the method of hastening the digestion of sludge by an artificial aeration, or, as it has now been called, by "activating" the sludge. Air is forced into sludge from the bottom of the tank in which it is stored and thereby agitates or activates the sludge, so that both an inoffensive condition and an accelerated aerobic decomposition have been maintained. Experiments are being conducted in several of our cities, and final results as to economical results when compared with other methods are not yet available.

Mr. H. W. Clark, Chief Chemist, Massachusetts State Department of Health and Director of the Lawrence Experiment Station, who has been continuing the classical work of the Massachusetts State Department of Health, begun about 1889, has recently again experimented on the treatment of sewage sludge. He states, in a letter, that since 1912 he initiated and developed a process of purifying sewage by aeration for the accumulation of "growths" in tanks containing layers of slate or other material placed in a nearly horizontal position, one or two inches apart. Air currents aid also in circulating the sewage between the slates and, in contact with the "growths", purify it in 5 hours. The process is said to have collected for removal from the Lawrence sewage 80 per cent. of the total suspended matter.

Mr. Clark further says that this aeration was viewed at Lawrence by Dr. Gilbert J. Fowler, of Manchester, in 1912, and was further investigated by him and other English workers, and that from it the process of "activated" sludge, a name given by Dr. Fowler, was developed.

Mr. Clark has also investigated sludge treatment in deep tanks and reaches the conclusion that the successful production of compact, inoffensive sludge depends upon the character of the sewage which produces it, and varies with slight differ-

ences in the chemical reactions within the tanks as well as in the methods of operating them. A slight agitation of the currents of air, water or sewage, or an increased alkalinity by the addition of lime, etc., gives, for some sludges, satisfactory results that cannot otherwise be obtained.

Mr. E. J. Fort, of Brooklyn, says that the results of his investigations seem to indicate, so far, that it is possible to purify sewage by forced aeration to any degree desired, but also, that because of the excessive expense, it is generally impracticable. He has not yet completed his experiments with "activated" sludge.

Mr. T. Chalkley Hatton, Chief Engineer of the Sewerage Commission of Milwaukee, is also experimenting with "activated" sludge, but, as with other experimenters, has not yet arrived at final conclusions. He is using Mr. Clark's suggested slate layers with enforced aeration and finds that after six hours a well nitrified effluent is obtained, as may be done in any properly operated contact bed with forced aeration, and in much less time in ordinary sprinkling filters. The sludge settles out in from 10 to 20 minutes and leaves a non-putrescible liquid. The sludge is well granulated and drains within a few hours to 50 per cent. of moisture content.

The U. S. Public Health Service, in Washington and the Baltimore Sewerage Commission have also recently begun to make tests on "activated" sludge and sewage aeration. The Engineering Record of March 6, 1915, in an article by L. C. Frank, Sanitary Engineer, U. S. Public Health Service, gives a review of the English previous experiments on that subject, as a preliminary to the Baltimore tests. In 1912, Dr. Fowler and in 1913, Mr. Ardern experimented on sewage aeration at Manchester, but similar experiments had before been made in the United States and in Germany. These gentlemen found that well aerated, or "activated", sewage sludge was capable of causing a well nitrified sewage effluent by bringing such sludge in intimate contact and mixture with raw sewage for from four to six hours, when the temperature was above 10 degrees C., and best at 20 degrees C. The process is essentially a biological one in both sludge and liquid, as has been known for many years. It is proposed at Baltimore to experiment in

a tank through which sewage flows continually, and to use an Imhoff tank for the purpose.

It will be interesting, in due time, to learn of the results obtained at these several experiment stations. There does not seem to be a question any longer that inoffensive decomposition of sewage can be secured by sufficient aeration—a fact that also has been known for a long time. Agreement, however, does not yet exist on the most effective and economical way of applying and diffusing the air. Whether or not the process of "activating" sewage sludge for an inoffensive disposal will be preferable, by substituting an aerobic for an inoffensive anaerobic decomposition, depends upon the element of comparative cost of both in securing and maintaining the desired unobjectionable conditions.

DISCUSSION

Mr. Bachmann.

Mr. Frank Bachmann* stated that screening removes relatively little of the putrescible matter in sewage, save when the sewage is fresh. Long sewers in Chicago allow considerable disintegration of the sewage, with the result that relatively little putrescible matter is ordinarily removed. The oxygen demand test (saltpetre test) is used to determine relative putrescibility. Most of the putrescible matter is in solution or in the colloidal state. Thirty percent may be removed by settling tanks. In the experiments at the Chicago stockyards, in which screening and sedimentation methods were tried, the Fowler process of activated sludge gave good results. The question of economy of operation has also to be considered.

In the activated sludge process 0.2 cu. ft. of air per minute per sq. ft. of area in tank 10 ft. deep with 6 hours' treatment gave excellent results.

Filtrose plates (to give complete mixing of air and sludge) were used in the distribution system.

Mr. von Greyerz.

Mr. W. von Greyerz,† Lieut. Royal Swedish Engineer Corps, referring to the comparatively large streams and small cities in Sweden, said that the problem of sewage treatment and purification is a recent one in that country.

He stated that for municipal sewage, closed tanks, but no artificial settling basins, have been in use for a number of years; during later years, however, several Imhoff tanks have been constructed and success-

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Mr. von Greyerz. fully operated. A depth of not less than 10 meters has proved to be desirable for obtaining a properly drainable sludge. The constructive details are varied of course to suit local conditions, but, generally speaking, the principles of construction as laid down by Dr. Imhoff have been followed.

In some cases, where the effluents from septic tanks have been found objectionable on account of their odor, etc., an inexpensive, yet effective, improvement has been obtained by constructing channels at each side of the tank (similar to those of an Imhoff tank), where the larger part of the suspended matter can settle and reach the septic tank through long, narrow openings along its sides. Because of the insufficient depth of these re-constructed tanks, the sludge is not drainable in the same efficient way as in a deep Imhoff tank, but the effluent has the same qualities as that from an Imhoff tank.

Where the sewage contains a larger amount of grease, it has been found necessary, in order to avoid difficulties with scum, to provide sufficient room for the scum at the sides of the settling channel. This has been effectively done by making the tanks in the shape of inverted cones, thus obtaining, with a depth of 10 meters and a sufficient sludge room, large scum rooms and a very economical construction. By daily agitation of the scum, produced by hand, the gases are easily removed and the scum thus caused to settle to the bottom.

Talking on filters for final treatment, the speaker said that contact filters have not been built for municipal use, but for smaller installations only. He considered percolating filters to be far more effective, and among them he preferred genuine sprinkling filters, with effective aeration of the sewage before it reaches the filter bed, compared with Dunbar filters, which may be useful where little head is available and pumping has to be avoided, but which in some cases have not given satisfactory results. Cold does not seem to affect sprinkling filters unfavorably.

Mr. Fuller. **Mr. G. W. Fuller,*** M. Am. Soc. C. E., desired to call attention to a few points of present-day interest:

In laying the collecting system, bituminous joints have insured absence of ground-water in the sewer, avoiding the production of head in the sewer and also the overloading of the sewage disposal works. The bituminous joints cost 5 to 8 cents more than ordinary joints.

In a system very carefully laid (2% for inspection), it was found on account of the number of connections made daily (about 40) that the house connections were being laid without suitable inspection and the result was that the increase due to ground-water infiltration greatly overtaxed the disposal works.

In many sewer systems, heavy deposits of sewage occur near the outfall and these are washed out with heavy storms. This is closely related to shell-fish pollution.

* Hydr. & San. Engr., New York., N. Y.

Should chlorination be applied to unsettled sewage for sterilization purposes? The answer is, No. Liquid chlorine is replacing Hypo for sterilization. Mr. Fuller.

State boards of health require sterilization and at present adequate devices for controlling liquid flow are to be had. Hypo presents difficulties in handling, clogging of feeding orifices, etc.

In tank treatment of sewage, the Imhoff tank is the greatest step made during the last decade, but it is not a cure-all.

Theoretically, a good sludge mixing and uniform bacterial growth lead to good results. Practically, overgrowths and localization of certain types of bacteria give rise to objectionable odors.

H_2S is probably always present; if the bacteria can carry the reactions to the end, no trouble will result. Interruptions in the process give rise to gas nuisances. Chemicals (lime) may be added to bring about such bacterial environment as to promote thorough action in the tanks.

The field of activated sludge is a most extensive one. Air is added to the sludge to promote bacterial growth and then this material is used to seed the tanks. An intimate mixture of the zooglia (such as formed in a sprinkling filter, and by a similar action) gives rise to a clarification by a coagulation of colloidal matters, a non-putrescible liquid and a lessened bacterial content.

The practice with regard to activated sludge is unsettled; winter and summer conditions differ, and conditions differ from place to place.

The economic questions relative to sewage treatment by activated sludge will entail an effort on the part of the engineer to control excessive sewage flow.

The relation of attendance and cheap power must be worked out. (A large city can solve a problem that a small one could not hope to attempt.)

Efficient management of treatment works is a prime necessity.

Engineers should retain control of plants for a year or two after completion of plants to insure proper operation and training of new attendants.

In reply to a question relative to the composition of bituminous joints, whether the process were expensive or patented, Mr. Fuller said that any bituminous material, where the danger of overheating is not great, may be used.

Dr. Gilbert J. Fowler† (by letter) stated that experience at the Withington Sewage Works of the Manchester Corporation bears out much of what Dr. Hering has stated in regard to the operation of the Imhoff tank. The necessity for periodically stirring the scum is a somewhat serious matter; if mechanical agitation is to be used it will introduce complication and cost. The statement that exposure to the Dr. Fowler.

* Atascadero, Calif.

† Manchester, England.

Dr. Fowler. air tends to increase putrefaction, appears *a priori* open to question and he would like rigid scientific evidence on the point. His experience with the Imhoff tank has confirmed him in his belief that the final solution of the sewage problem is not to be found in processes involving anaerobic action, but on the lines of aeration, putrefaction being avoided at every point.

The history of the development of what has come to be known as the ''activated sludge'' process is carefully given in the first paper by Messrs. Ardern and Lockett (Jour. Soc. Chem. Ind., No. 10. Vol. XXXIII. May 30th, 1914).

The articles which have recently appeared in American technical journals, describing experimental work at various centres, are clear evidence that the work of the English investigators marks an advance on anything previously accomplished.

It is matter for satisfaction that the interchange of scientific work on both sides of the Atlantic should eventuate in progress for the general good.

The question of priority, where so many workers are involved is of small importance in itself; when, however, statements are made by Dr. Hering and others which obscure the scientific understanding of the process, it is important that they should be corrected.

It is quite true that he (Dr. Fowler) was much impressed by Mr. Clark's work at Lawrence, and to the Massachusetts workers is due the idea of building up, by prolonged aeration of successive quantities of sewage, a growth which would rapidly purify sewage in the presence of air. But the question of expensive surfaces, difficult to construct and handle, still remained, and because of this, the possibilities of the process were not favourably considered by the Metropolitan Sewerage Commission, with whose president the matter was carefully discussed. The writer, therefore, returned from New York considering the problem of how to bring about purification in open tanks with, at any rate, the least possible addition of costly chemical precipitants. The idea of adherent growths was therefore abandoned in favour of some process of bacterial or enzymic activity, a line of thought which had previously been present in the mind through a suggestion of Dr. Maclean Wilson's (Jour. Soc. Chem. Ind., No. 23. Vol. XXX, p. 1348, 1911). From this line of thought was developed what has come to be known as the ''M7'' process, which was described in a paper by the writer and E. M. Mumford at the Congress of the Royal Sanitary Institute at Exeter in July, 1913.

By this method, a bacterium discovered in colliery waters, termed ''M7'', was made use of which had the property of precipitating hydrated oxide of iron from solutions containing salts of iron, together with organic matter.

Sewage from which the grosser solids had been removed by sedimentation was treated with a small quantity of iron salt and inoculated

with the organism referred to, and aerated for several hours. Perfect clarification took place, and a deposit containing a very high percentage of nitrogen (as much as 10%) was formed. Dr. Fowler.

The effluent from this process could be nitrified at very high rates on percolating filters.

Inasmuch as preliminary settlement of the sewage was called for by this process, with production of ordinary sludge, and as the effluent still required final treatment on filters for complete oxidation, the method, although having many advantages, did not completely realise the object of the researches.

In the development of the field experiments in connection with this process, valuable practical experience on the economical application of air, was, however, gained. Contemporaneously with this work, experiments were being carried on at Davyhulme, at the writer's suggestion, on the continuous aeration of successive quantities of sewage, as in the Massachusetts work, and these experiments resulted ultimately in the activated sludge process described in the various papers of Messrs. Ardern and Lockett.

It is now possible to correlate the various results which have been obtained and to get some steps nearer to a proper understanding of the nature of the process. The writer's present view is that it can be referred entirely to bacterial activity. It was distinctly stated, in the first paper by Messrs. Ardern and Lockett, that their sludge did not contain any algal growths; the process thus differs essentially from that which was in operation at Lawrence at the time of the author's visit and which was subsequently described in the Annual Report of the Massachusetts State Board of Health for 1913, p. 289 et seq. It would appear, therefore, that the activated sludge process consists, broadly, of three operations: a clotting or clarifying action; a rapid carbon oxidation process; and, finally, nitrification. It is probable that the first process is, to some extent, the result of the activity of organisms similar in character to "M7" which was definitely shown to depend on enzymic action, whereby traces of iron appeared to start the flocculation of the whole sewage. The "M7" bacillus is probably fairly ubiquitous, as it has been found that sewage containing iron and a certain amount of partially activated sludge, but in which clarification has not been effected, can be made to clarify almost at once by the addition of a small quantity of properly activated sludge. Simultaneously with clarification, the organic matters in solution follow the usual course of oxidation, which takes place rapidly owing to the enormously extended area of bacterial activity. In the writer's opinion, the outstanding advantage of the process lies in the fact that the sewage is really clarified and the process of clarification results in the precipitation of the emulsified nitrogenous matter in the sewage. This has hitherto not been arrested in any process of tank treatment, with the possible exception of certain precipitation processes which involve the

Dr. Fowler. addition of large quantities of costly and inert chemicals. Experiment has shown that bacterially precipitated sludge is quite extraordinarily active as a manure and there seems every reason to believe that an important step has been taken in the ultimate aim of economic sewage disposal, viz., the return of nitrogen to the land.

A great deal of research remains to be done on the conditions of activity of the sludge, both as an agent in sewage purification and as a manure, but advance is only possible by patient and exact biochemical investigation, and it is of the utmost importance that unfounded assumptions and short cuts of all kinds, which have been responsible for so much waste of public money on sewage treatment plants in the past, should be avoided.

It cannot be too strongly emphasized that the proper treatment of sewage is a matter, in the first place, for the scientific specialist; when he has worked out the governing facts of the situation, it remains for the engineer economically to construct the plant which fulfils these conditions.

In the present case, the engineering problem is a comparatively simple one; it is merely to keep the activated sludge uniformly mixed with the sewage in presence of the necessary air. A large amount of work has been done in this country, and also by Mr. Chalkley Hatton at Milwaukee and Dr. Bartow at the University of Illinois in collaboration with the writer, and experimental plants of various dimensions capable of dealing with quantities varying from 60,000 gallons to as much as 2,000,000 gallons per day are in course of operation or construction.

In all comparisons of cost between one process and another, it is essential that result should be compared with result. Unfortunately, this rule is not always adhered to and a given process, e. g., is said to be cheaper when in examination it gives much less satisfactory results. Where strict comparison is made, the advantages of the activated sludge process are, in the majority of cases, beyond question, and the writer considers that any further large expenditure on works of the conventional type is—in view of the results already obtained—seriously to be deprecated.

Mr. Greeley. **Mr. Samuel A. Greeley,*** Assoc. M. Am. Soc. C. E. (by letter), referring to the new process of treatment with activated sludge, said that new data are accumulating so rapidly and there has been so little time for its study, that an opinion of its value relative to other methods of sewage treatment must, for the present, be kept open. The results on an experimental basis in warm weather are very promising. The reliability of the process, from season to season, under municipal management and the cost of operation are still undetermined factors.

The writer concurs with Mr. Hering's statement of the value of building sewers with smooth surfaces and proper slopes to give cleansing

* San. Engr., Winnetka, Ill.

velocities. These questions are of particular importance in the flat areas of the Middle West, where the temptation is great to avoid the annual cost of pumping by using very flat slopes. The writer knows of several places where nuisances have occurred on this account. The bad conditions have been aggravated, in certain instances, where industrial wastes have been discharged into the sewers. The practice, however, persists, even where the topography permits of good slopes. Mr. Greeley.

With reference to the discharge of sewage from the end of the sewer, the writer wishes to call especial attention to methods of discharge into a stream. Quite often the sewer is stopped at the edge of the water or at some distance from the edge. The sewage collects in pools, deposits occur, septic conditions follow, and nuisances result. Care should be taken to mix the sewage with the water in a stream in such a way as to eliminate these offensive conditions. A poorly designed outfall may partly destroy the value of good grades.

Mention should also be made of the growing appreciation of the value of river regulation as a factor in sewage treatment. Intensive studies of the behavior of streams carrying raw sewage or sewage effluents, are being made now in several localities. Removing obstructions from a stream may lower the water level and give enough additional head to operate treatment works without pumping. Storage reservoirs may be advisable to maintain a flow during extremely dry seasons. The growth and action, in quiet water, of micro-organisms and other forms of plant and animal life and their place in sewage treatment are matters of much interest and value.

Mr. G. S. Webster,* M. Am. Soc. C. E. (by letter), called attention to the author's statement regarding the decomposition of sludge in an Emscher tank, and to the trouble which may arise from an acid reaction in the tank. He instanced the experience at the Pennypack Creek Sewage Treatment Works at Philadelphia. Mr. Webster.

The sewage from the village of Holmesburg and three adjacent municipal institutions is intercepted and passed through a treatment works consisting of grit chambers, Emscher tanks, percolating filters, disinfection with calcium hypochlorite and final settling basins, to protect from pollution Pennypack Creek, which discharges into the tidal Delaware River about 2000 ft. south of the intake of the Torresdale Water Filters, which provide two thirds of the city's supply.

About two thirds of the contributing population to the sewage works are in the County Prison, House of Correction and Home for Indigent. In these institutions generally breakfast consists of bread and coffee; supper, of bread and tea or cocoa; and dinner, of bread and soup or stew made of meat and vegetables. In the Home for Indigent, roast meat and vegetables are sometimes used for dinner, and either stewed fruit or cereal for supper. This diet is highly carbonaceous and lower than normal in nitrogen.

* Ch. Engr. and Surv., Bureau of Surveys, Philadelphia, Penna.

Mr. Webster.

After the works were put in service in December, 1912, it was unnecessary to withdraw sludge for many months, as the storage room was ample.

It was not expected that these tanks would mature as rapidly as those receiving a normal sewage.

The sludge withdrawn during the early periods of operation was dark but not black, contained gas but did not readily dry, contained objects which had not broken down into the granular state found in good Emscher tank sludge and was not devoid of bad odor. Furthermore, each withdrawal of sludge failed to show the usual improvement in quality as tanks ripen.

Analysis of the sludge showed it to be acid, some samples containing as much as 2200 parts per million. As a large part of the acidity was removed by boiling the sample, it was concluded that the decomposition of the carbonaceous material was producing more carbonic acid than the ammonia produced by the hydrolysis of the nitrogenous matter could neutralize, and also that an abnormal quantity of fatty acids was present in the sludge.

Barrels were set up over the ventilator of each tank and lime-water added to the sludge by means of a pipe extending through the ventilator and terminating about mid-depth of the sludge. The rinsing water was used more liberally than usual, to wash away the toxic matters and to cause an agitation and mixture of the mass. Thereafter each successive withdrawal of sludge showed less acidity, until finally the sludge is nearly alkaline when tested cold and highly alkaline when heated.

As its acidity was neutralized the quality improved, until that now drawn is entirely inodorous, parts with its water quickly, so that it can be removed from the drying beds in a few days, is black, granular and flows readily, although low in moisture.

Mr. Roechling.

Mr. H. Alfred Roechling,* M. I. C. E. (by letter), referred to the supreme importance of public health and expressed the view that purely as a matter of self interest (not to put it on higher grounds), as a matter of the utmost economic importance, the efficient sanitation of towns stands foremost in a long series of health measures, which should be encouraged by the authorities. And in all health measures it must be borne in mind that efficiency is the first and foremost consideration. This does not mean extravagance, but it means that a compromise between efficiency and cheapness at the expense of efficiency is bad, and as a rule most expensive in the long run; whereas, the most efficient scheme is bound to be the cheapest in the long run. The influences on health are many, and they are frequently very subtle; and as we are not yet in a position to recognize all specific causes, or even to assign for every empirically recognized effect its true cause, we are bound to adhere to the old saying, "Prevention in health matters is better than cure", and that health is the best asset of communities and individuals.

And as to efficiency, it is here that the experienced and skilled engineer finds his true scope. Being fully conversant with all points that

* Consulting Engineer, Westminster, England.

Mr. Roechling.

require consideration, he should not come to a new town with pre-conceived notions, but should study, as it were, every case *de novo,* so as to fully understand the problem with which he is faced. He should carefully study the physical features of the ground, the atmospheric conditions, the geological aspect, the characteristics of the mode of living of the people, the health and other vital statistics, the trade activities, the financial conditions, the movements of the population, the growth of the town and many other points, to all of which he must attach their due weight, and when he has thus found the equation, as it were, which is represented by the case, he must try and find the proper solution for it as a whole.

In connection with the smells in public sewers mentioned by Dr. Hering he recalled a case abroad some time ago showing the great difficulty of avoiding them unless the scheme has been well designed, carefully carried out, and is well superintended. A town had extended its sewerage system and, in connection with it, had constructed a long main outfall sewer to discharge the sewage far below the town. In one of the large chambers of this outfall sewer, very enticing refreshments had been provided, but just as the party was trying to enjoy them, a very concentrated smell of sulphuretted hydrogen was wafted down the long length of the outfall sewer with the result that the refreshments were left untouched and the inspection was completed without any further waste of time. This was a completely new sewer which had never carried any sewage, and the smell must have come from a point at least a mile higher up.

He called attention to the importance of proper management for a system of sewers and for a sewage-disposal plant. He was inclined to think that the success of any well designed sewerage and sewage-disposal scheme is very largely a question of management. A good manager may obtain remarkable results even with indifferent works, whereas a bad manager will not obtain good results even with the best works. An intimate knowledge of the subject is the first essential of a good manager and the next is the requisite experience.

Regarding the separation of the suspended matter from the liquid, he referred to the construction of two-story tanks or of two separate tanks, one for the settlement of the sludge and the other for the putrefaction of the sludge thus produced. He stated that such a process requires, at the best, large tanks and takes a very long time, and that for this reason, others have turned their minds, in order to attain this result, to the centrifugalizing of the sludge. There are, he understood, quite a number of centrifuges at work, which are said to give good results. He referred to a report lately issued in which it is stated that in a particular centrifuge, in a very few minutes, a sludge cake containing on an average 60% of moisture was produced. As regards the degree of separation, the results are stated to have been as follows:

With a weak sewage, the liquid remaining only 10 seconds in the machine, over 80% of the suspended solids were removed.

With a stronger limed sewage, the liquid remaining only about 36 sec-

Mr. Roechling. onds in the machine, over 90% of the suspended solids were removed; and with a sludge containing 92.9% of moisture, the sludge remaining about three minutes in the machine, over 99% of the suspended solids were removed.

He desired to add a final word regarding the future of sewage disposal. He was reminded of the opinion of a friend who believed that the time is coming when no longer large and extensive works at a great distance below the town will be necessary and when their place will be taken by works in or near the town, perhaps somewhat after the Radial System employed in Berlin, in which the sewage if not at once treated by centrifuges will be submitted to a short preliminary treatment of settlement in special tanks sufficient for the purpose. The effluent from these would then be passed through a series of mechanical filters and the sludge through centrifuges. The sufficiently purified liquid could then be discharged into the river and the sludge manufactured into a commercial product, the liquid from the centrifuges being returned to the sewer.

At present such a stage has not been reached, but there can be no doubt that it would simplify matters, and as we live in an age of invention and progress, he believed the idea well worth bearing in mind and working for.

Mr. Dibdin. **Mr. W. J. Dibdin,*** F. I. C., F. C. S. (by letter), referring to the author's statement regarding Mr. H. W. Clark's process initiated in 1912, desired to state that after a lengthy series of experiments in his own laboratory, with London sewage obtained from the Pimlic Pumping Station on the Thames Embankment, he had patented the Slate Bed Process in 1903. The first experimental beds on a working scale were put down at Devizes in 1904 and as a result of the success of these the system was adopted for the whole of the sewage, which was turned on to the new completed slate beds on September 12, 1905.

Since that date the whole of the sewage of Devizes has been treated on those beds, viz., during 11 years, with the result that the sludge question there has been entirely set at rest.

The successful application of the system to a very large number of sewage-purification works has only confirmed the correctness of the method. The process has been repeatedly described by me in various papers read before technical societies.

The Royal Commission on Sewage Disposal in their Seventh Report definitely stated that "Provided that the sewage is not allowed to remain in the slate beds, the slate-bed sludge differs from ordinary sewage or septic tank sludge in that it possesses only a slight odour resembling that of sea-weed, and that it is full of minute forms of animal life. When examined under the microscope the number of *motile vibrios* is a striking feature. Numbers of small worms are also to be found in the sludge as it lies on the slates. * * * * * Investigations by Dr. G. J. Fowler and others, go to show that the organic matter of the sludge (apart from

* Analytical and Consulting Chemist, Westminster, England.

worms and other small animals present) is in an active process of inoffensive decomposition, as it lies on the slates. * * * * * This sludge possesses a strong sea-weed, but not offensive, odour. * * * * * On two occasions when a slate bed was opened, no offensive odour could be detected in the bed, even when standing on the bottom of it on a hot day. In fact, it smelt no worse than an ordinary damp cellar.'' Mr. Dibdin.

He considers this extract sufficient to show that the disposal of suspended matters in sewage not only can be, but has, for the past 11 years, been economically and satisfactorily accomplished on the slate beds introduced and worked by himself in practice apart from laboratory experiments, and continuously since 1904.

The rate at which slate beds can be worked depends upon the quality of the sewage, the controlling factor being the quantity of solid matter rather than the volume of water, the rate depending upon the quantity of oxygen which can be supplied, either in the form of atmospheric oxygen or oxygen dissolved in the water. Anaerobic action must not be resorted to as a preliminary treatment.

The inoffensive decomposition of sludge, and therefore the whole difficulty of the sludge question, is thus definitely settled by this method.

The sludge nuisance was in reality settled years before, by those who would use the method, by the original coarse contact beds wherein the solid matters were retained and subjected to the same process as in the slate beds. The only difficulty in that case was that the humus resulting from the action of the organisms on the organic matter was caught between the particles of clinker, etc., and caused the ''choking'' of the beds, especially when they were worked too rapidly. This was in many cases obviated by taking out the clinker and putting it aside to ''weather'' for a time, using a reserve supply for refilling the beds. This was considered an objectionable feature in view of the claims of ''No Sludge'' by some methods, and to overcome it he adopted the method of slate filling, which, whilst giving twice the working capacity, allowed the humus to be carried out of the beds by the escaping effluent and thus maintain their working capacity without the necessity of flushing or other cleansing.

With these beds there is no necessity for the daily expense of artificial aeration, as the natural processes are ample.

Mr. Fort.

Mr. E. J. Fort,† M. Am. Soc. C. E. (by letter), referring to the experimental work on sewage disposal which had been mentioned by the author, said that it is possible by means of forced aeration, without the employment of the activated sludge process, but with simple tankage of sewage with the application of compressed air introduced through a grid of perforated pipes or porous discs placed at the bottom of the tank, the aeration being followed by sedimentation in an ordinary secondary settling tank, to produce a very well clarified effluent having a satisfactory grade of stability, with the use of 20 volumes of air per volume of sewage,

† Chief Engineer of Sewers, Borough of Brooklyn, N. Y.

Mr. Fort. in a continuously flowing tank with a period of retention of 24 hours. The cost of this process however, in charges for operation, maintenance and overhead expenses, renders it incapable of competition with well-known and satisfactory methods of sewage treatment.

During experimental work in 1914, the principle of activated sludge was not appreciated, although the phenomena were observed and experiments were planned for a comprehensive study when new experimental work was cut short by the early appearance of cold weather in the fall of 1914. It was thought best to carry forward only the investigation which had been in operation during the summer, and defer new work along these lines until the spring.

With the publication of the results of activated sludge investigations in England, the plans for experimentation took a definite form in this direction, and it was determined to convert one experimental unit, known as the "tank aerator", into an activated sludge producer.

The "tank aerator" had been in continuous use during 1914, except in extremely cold weather, on sewage aeration experiments. In order to adapt it to the purpose of conducting activated sludge experiments, it was only necessary to provide an additional outlet pipe about one third of the distance up from the bottom of the tank.

The tank, which has 16,000 gallons effective capacity, is 12 ft. in diameter and 25 ft. 8 in. in height. A grid for supplying compressed air is placed on the bottom, and 7½ in. of broken stone which passes a 2-in. ring and is retained by a 1-in. ring is provided to support it. The same depth of the same broken stone is placed over it, so that the air supplied to the tank contents passes upward at first through the voids in the broken stone. The outlet as originally installed is about 1 ft. above the surface of the broken stone, so that in all aeration experiments, about one twentieth to one twelfth of the contents of the tank was retained at each emptying. The new outlet for the activated sludge investigation is so placed that 6000 gallons is retained in the tank at each drawing.

The operation of this tank was initiated in the middle of March, and the slow process of accumulating activated sludge and bringing the liquid to stability took until June 1. By May, the results with 24 hours' aeration were excellent. On June 1, operation was commenced on the following schedule: At 8 A. M. air was shut off and sewage was allowed to settle for one hour; at 9 A. M. drawing off of supernatant was commenced, discharging 10,000 gallons; at 10:30 A. M. drawing was completed, and air was again turned on. The tank was then refilled with crude sewage; at 12 noon, refilling was completed. This cycle has been continued up to the present time. Besides its interest and value as an experiment, this tank has been especially useful as a source of supply from which to take ripe activated sludge for starting other experimental units in which the phenomena are under investigation.

The results for the month of June, 1915, are shown in the following table:

Mr. Fort.

	Refill			
Hours Aeration after Refilling.	0	2	5	20
Volumes of air per vol. of sewage	1.17	3.50	7.00	24.55
Dissolved oxygen, P.P.M.	0	0.1	0.4	2.5
Relative stability, %	15	38	62	100
Oxygen demand (biologic), P.P.M.	56	42	....	8
Suspended solids, P.P.M.	35	24	20	14
Nitrogen as nitrites, P.P.M.	0.08	0.11	0.49	1.5
Nitrogen as nitrates, P.P.M.	0.1	0.6	1.2	7.3

''Refill'' refers to sample taken immediately upon refilling the tank, which takes one and one-half hours, the air being on in the interval.

The sewage used to fill the tank has the following average composition:

Dissolved oxygen, P.P.M.	1.0
Relative stability, %	3
Oxygen demand (biologic), P.P.M.	200
Nitrogen as nitrites and and nitrates	Trace

In view of the complications involved in the operation of a sewage-disposal plant with tanks on the fill-and-draw plan, and with the hope of effecting a saving in the expense, studies were commenced in May of this year for the design of a tank which should treat the sewage on the continuous-flow plan. Such a tank was put in service on July 14, since which date it has been in constant operation. This tank is of wood staves, and is placed conveniently adjacent to the tank aerator, so that it can be filled therefrom readily with ripe activated sludge. It is 54 inches in clear diameter and 8 feet deep and its capacity is 900 gallons. The bottom of the tank is an inverted truncated cone, in which are placed five carborundum air diffusers. The sewage is admitted near the bottom. Meters are provided for both air and sewage. A stilling chamber is installed in the top of the tank in the form of an Imhoff sedimentation chamber.

The design of this unit approximates that of an Emscher tank with horizontal flow. The portion corresponding to the digestion chamber of the Emscher tank is employed as an aerating chamber, the activated condition of its contents being constantly maintained. Into this activated mass the crude sewage is continually admitted, being mixed therewith by the compressed air which keeps it in constant agitation.

The treated sewage enters the sedimentation chamber from the aerating chamber over a weir at the surface and to some extent through the slot at the bottom. A quiescent condition of the sedimentation chamber is at all times maintained, and a high degree of clarification secured in the contents, no bubbles of compressed air entering it. At times some trouble is experienced from whirls, or stray currents, arising through the slot, and causing the appearance of flocculent suspended matter in parts of the otherwise clear contents. This difficulty can probably be overcome by making the slot smaller, and indeed it would probably not appear in a tank of ordinary working size. It has not

Mr. Fort. at any time prevented the continuous discharge of a clear effluent from the tank. The flocculent matter in the activated sludge brought into this chamber by the sewage passing through it settles out, and reënters the aerating chamber through the slot, through which it slips readily. The sedimentation chamber has a capacity of 100 gallons.

This tank was charged when put into service with activated sludge from the tank aerator, and crude sewage was admitted at the rate of 95 gallons per hour, giving a retention of about 8½ hours in the aerating chamber. Air was applied at the rate of 0.7 cu. ft. per minute. This resulted in securing a very well clarified effluent with an oxygen demand which averaged 27 P. P. M. This, however, would be satisfactory as an effluent for discharge into our waterways, especially as it was practically free from suspended solids.

The cost of treating sewage by the activated sludge process depends upon so many factors and circumstances that it would be scarcely possible to offer any adequate, or even reasonable, estimate at this time which would be of general value.

A few data on the cost of current to supply power for producing the aeration may be of interest, but should be prefaced with the statement that they are based upon a maximum-demand contract with a wholesale rider as provided by the Brooklyn Edison Company.

The continuous-flow tank experiment indicates that with this method installed for treating twenty million gallons of sewage per day at our plant, using 442,200 cu. ft. of free air per million gallons, and applying the air under a gauge pressure of 5 lbs., the cost would be $2.55 per million gallons treated, or $51.00 per day for the current alone for treating twenty million gallons with air.

The cost of the fill-and-draw method in a deep tank with a minimum retention requiring five hours' aeration with one volume of air per hour per volume of sewage, and with the air applied under a gauge pressure of 10 lbs., on account of the depth of the tank, as in our tank-aerator experiment, would cost about $7.00 per million gallons treated, on the basis of treating twenty million gallons per day.

It would seem, all things considered, that the continuous-flow method offers some promise of success, but that the fill-and-draw method and the treatment of sewage by plain aeration are not very promising, on account of cost, when compared with well recognized and successful methods now in use.

Dr. Hering. **Dr. Rudolph Hering** (by letter), in closing, expressed great pleasure in observing how almost unanimous were the opinions on the subject of the paper, and how progress is rapidly proceeding towards a satisfactory goal.

Dr. Gilbert J. Fowler, referring presumably to the question of activated sludge, refers to statements "made by Dr. Hering and others, which obscure the scientific understanding of the process". Dr. Hering has carefully searched his paper for any remarks by which he may have

Dr. Hering.

obscured the understanding. He finds that the only personal opinion he gave concerning this process is contained in the last paragraph, where he says: "Whether or not the process of 'activating' sewage sludge for an inoffensive disposal will be preferable, by substituting an aerobic for an inoffensive anaerobic decomposition, depends upon the element of comparative cost of both, in securing and maintaining the desired unobjectionable conditions."

Dr. Fowler very fully states his own understanding of the process, which, as he was one of its originators, is authentic. Dr. Hering feels that a word may be added regarding his words—"inoffensive anaerobic decomposition". Under ordinary conditions, anaerobic decomposition of sewage may be, and usually is, quite offensive, caused chiefly by the generation of sulphureted hydrogen. Note privy vaults, cesspools, septic tanks, and generally such conditions where sewage is exposed to the atmosphere long enough for an exhaustion of the oxygen, which is immediately available for the decomposition, and therefore produces an anaerobic process of decomposition. We call this process putrefaction because it is offensive.

In the Imhoff tank, the sewage sludge in the lower story has also practically all of its oxygen exhausted, and therefore also exhibits an anaerobic decomposition. But the process is not offensive, and it is, therefore, not putrefaction. The gases developed are practically all non-odorous, about ¾ being methane and about ¼ carbon dioxide, hydrogen and trifling amounts of other gases. No sulphureted hydrogen is noticeable, nor is this process on oxidation, as in the case of activated sludge, sand or sprinkling filters. A new word is needed to indicate this "inoffensive anaerobic decomposition". Asepticity would at least describe the condition.

To Dr. Hering it seems curious for Dr. Fowler to say that "the proper treatment of sewage is a matter . . . for the scientific specialist" to work out, and that it merely "remains for the engineer economically to construct the plant". It so happens that the Imhoff tank, built about eight years ago and now superseding the septic tank in all countries, was "worked out" by an engineer, and to his own knowledge, its scientific basis, now generally acknowledged, was at first not acknowledged by prominent scientific sewage chemists and biologists in Germany, England and America.

Paper No. 57

SEWAGE TREATMENT BY THE ACTIVATED SLUDGE PROCESS.*

By

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In his paper, "The Disposal of Suspended Matter in Sewage", Dr. Hering has briefly but completely summed up the most satisfactory methods prevailing today of treating sewage from those larger communities in the United States which have undertaken the work. He has concluded his paper by introducing a new process which has, of late, received the earnest attention of many engineers and chemists engaged in solving the problem of sewage treatment, and has very courteously invited discussion upon this process.

The name so far given to this new process is "Activated Sludge", and, in the light of present information, this name is extremely applicable, because the active micro-organisms contained in the sludge appear to perform the burdens embraced in the purification of the sewage. However the process must not be considered as a sludge digestion process only, as is suggested by Dr. Hering, but as a complete purification process, requiring only the subsequent disposition of the resultant sludge.

A brief engineering description of the "activated sludge" process is, the scrubbing of sewage liquor by means of air artificially injected throughout its mass at low pressure and of suffi-

*This paper was presented as a discussion of the paper by Dr. Hering. Inasmuch as it treats more fully the details of the activated sludge process, it is published in form as a supplementary paper on the general subject of sewage disposal.

cient volume to separate suspended matters and colloids which form a sludge, kept in constant and thorough agitation throughout the body of the liquor. The sludge, thus kept in contact with the liquor, must contain sufficient reducing and nitrifying organisms, and adequate food and lodging therefore, to break down the organic nitrogen into free ammonia and nitrogen, and to oxidize these to nitrates.

We admit that the above description is not scientific, but it suggests the vital points the engineer must consider in designing his plant.

A more scientific definition may be stated as follows:

The sludge embodied in sewage, and consisting for the most part of organic matter, when agitated by air for a sufficient period, assumes a flocculent appearance very similar to small pieces of sponge. Bacteria gather in these flocculi in immense numbers, some of them having been strained out of the sewage and others developed by natural growth. Among the latter are species which possess the power to decompose organic matter, especially of an albuminoid or nitrogenous nature, setting the nitrogen free, and others absorbing this nitrogen convert it into nitrites and nitrates. These biological processes require time, air and favorable environments, such as suitable temperature, food supply and sufficient agitation to distribute them throughout all parts of the sewage.

Experiments have been carried out in many places and for many years for treating sewage by aeration, but so far as our information goes, such experiments have never embraced the aeration of the combined liquor and sludge while being intimately mixed. The air as an oxidizing agent has been worked to its maximum, while the reducing and nitrifying agents have been largely left to shift for themselves, with the natural result that the cost of purification proved excessive because some of the most efficient agents in the process were only partially worked.

Messrs. Black and Phelps, in their studies of the sewage disposal problem for New York City (Mass. Inst. of Technology, Vol. VII), investigated the applicability of aeration primarily with a view of separating the solids from the liquor and preventing them from being deposited into the harbor. In these studies

the efficiency of the nitrifying agents was not recognized, the coagulating tendency of the air being the main purpose.

Messrs. Clark and Adams, in their experiments with slate tanks, at the Lawrence experimental station (Engineering Record, Feb. 7, 1914, page 158), fully utilized the oxidizing agents, but failed to appreciate the full work which could be obtained from the reducing and nitrifying bacteria. Professor Gilbert J. Fowler of the University of Manchester, England, was no doubt the first to discover such conditions as would enable all of these purifying agents to do their most efficient work. In his discussion before the Society of Chemical Industry, Manchester Section, May 30, 1914, he very handsomely gives the credit for his discovery to the experiments being carried out by Mr. Clark at the Lawrence experimental station, but after carrying out experiments with the Clark slate process on a large scale for nine months in our testing station at Milwaukee, we have reached the conclusion that the two processes are not comparable either in physical conditions or results.

During 1913 and 1914, Mr. Edward Ardern and Mr. William T. Lockett, of the Rivers Committee of the Manchester Corporation, in collaboration with Professor Fowler, carried out exhaustive laboratory experiments upon the purification of sewage by aeration in the presence of activated sludge. A résumé of their work was presented in a paper before the Manchester Section of the Society of Chemical Industry on May 30, 1914, and disclosed results which had never before been obtained by any process of sewage treatment by artificial aeration.

Soon after the publication of this paper experiments were begun in a number of places in the United States to try out the process. Mr. M. N. Baker, in Engineering News, July 22, 1915, page 164, gives a list of these places, which include Washington, Baltimore, Chicago, Urbana, Brooklyn, Brockton, Cleveland, Lawrence, Houston, Milwaukee and Regina, Sask.

It is interesting to note that no other new process of sewage treatment has been so intensely studied by so many experimenters within the short period since its discovery. Among the reasons for this may be mentioned its applicability to diverse conditions, small area required for treatment, ease of control, a complete process within itself, and, incidentally, the probable

value of the resultant sludge, although little definite information has so far been published upon the last named feature.

Experiments upon the activated sludge process are being carried on perhaps upon a larger scale at the Milwaukee experiment station than at any of the other places mentioned. Up to July 1, 1915, the tests were conducted upon the fill-and-draw method, a detailed description of which, and results obtained, were fully set forth in the Engineering News, July 15, 1915, and need not be here repeated, except to add that further experiments have been made with a view of determining the point where the curve showing volume of air per minute used for aeration crosses the curve showing time of aeration necessary for certain standards of purification.

The experiments carried on by Messrs. Ardern and Lockett, at Manchester, and those by Prof. Edward Bartow, at the University of Illinois, as described by him in a paper appearing in the Journal of Industrial Chemistry, Vol. 7, April, 1915, page 318, have been based upon the fill-and-draw principle, these gentlemen appearing to be quite pessimistic as to the efficiency of the process if the continuous-flow principle was adopted.

In spite of this pessimism, however, we, in charge of the Milwaukee experiment station, decided to give the latter principle a complete trial. To that end we constructed a continuous-flow tank alongside of the fill-and-draw tank, and of the same size and capacity. A plan of this tank is shown on page 137, Engineering News, July 15, 1915. This tank was improvised from an abandoned chemical precipitation tank and was not applicable to the designs we would have embraced in a new tank. A month was required to seed this tank with "activated sludge" before the continuous flow could be begun.

It may be interesting to describe how this activated sludge was obtained. The anaerobic sludge from an Imhoff tank was run into the continuous-flow tank to twenty-five percent of its volumetric capacity. This was then constantly aerated, fresh raw sewage being added every six to ten hours to the full capacity of the tank upon the fill-and-draw method. This was continued for several days until the sludge was quite brown, the liquor decanted from the tank was limpid and contained nitrates, and the free ammonia had practically disappeared.

To those who may be considering making experiments with this process, it might be suggested that no satisfactory results can be obtained until activated sludge is obtained. The quantity in the tanks operated, necessary to get the best results, has not yet been determined, but we have conducted our experiments with a view of maintaining at least twenty-five percent sludge in both the fill-and-draw and continuous-flow tanks.

Good results can be obtained in the removal of bacteria without establishing the nitrogen cycle, although the effluent is not as stable as when it contains two or more parts per million nitrates.

Since the last week in July we have been operating the continuous-flow tank with remarkable results. During this period many experiments have been conducted to determine the most economical volume and rate of air to secure different standards of effluent and to control the sludge. Several changes had to be made in the tank from time to time for the latter purpose, so that we have been unable to operate the tank continuously for any considerable period, but from records so far secured we have no hesitation in making the statement that, with 0.25 cubic feet of air per minute per square foot of tank surface, which, in this case, is equivalent to 1.77 cubic feet of air per gallon of sewage treated, and with an influent containing about 250 p.p.m. suspended solids, the effluent has been clear and limpid, containing no suspended solids, nine parts of nitrates per million, stable after 5 days, and a bacterial reduction of over 98%.

Basing our computations upon a plant treating fifty millions or more gallons of sewage per day, the cost of compressing air to five pounds pressure is $2.50 per million cubic feet of free air, which includes all boiler room and overhead charges, such as interest, sinking fund and depreciation.

Assuming that the results, as stated in the foregoing statement, can be realized in a working plant, the cost for air will be $4.32 per million gallons of sewage treated, and these results are far superior to those we have obtained by treating the same liquor by means of Imhoff tank and sprinkling filters having 8 feet depth of stones. From present indications we feel that these costs can be greatly reduced and we are now conducting experiments with this end in view.

SLUDGE.

One of the remarkable features of this process is the character of the sludge produced and its tendency to quickly settle. It has the general appearance of small particles of brown sponge, and flocs together very rapidly, settling almost like sand. From the aerating chamber, where the liquor and sludge are brought into intimate contact by means of the diffusion of the air, the mixture is discharged into the sedimentation chamber about three feet below the surface of the liquor. The sludge immediately drops to the bottom of the chamber, the clear liquor rising to the surface. It is this tendency which cuts down the sedimentation area so necessary in other precipitation processes. Twenty to thirty minutes' running-through period is all that is necessary for even the fine comminuted floc to disappear from the upper strata of the effluent.

The sludge is not sticky nor gummy as is Dartmouth tank sludge, nor does it appear to be as cellular as Imhoff tank sludge. It is easily dewatered, however. Experiments conducted with the Imhoff tank sludge and the activated sludge indicate that the latter is dewatered much more rapidly than the former.

Up to the present time we have not been able to secure reliable data as to the accumulation of sludge from the process, for the reason that we have required all the sludge we could procure from our station to carry on the several experiments relating to the process.

As the sludge is drawn from the tank it contains from 96% to 98% of moisture. Record of a recent test of dehydrating is as follows:

	Moisture	Reduction in Volume
Original sludge	96.7%	
After 24 hrs. draining	86.2%	78%
After 48 hrs. draining	82.9%	82%

The sludge to the depth of 10 in. was placed upon the surface of an ordinary drying bed as used in connection with treating Emsher tank sludge.

A two-gallon sample of the sludge taken from the fill-and-draw tank was sent to a company in Chicago engaged in the

manufacture of fertilizer from by-products. Its report is as follows:—

Moisture	3.3%	Ammonia	5.45%
Total P. A.	1.84%	Potash	0.23%
Insoluble P. A.	0.50%	Nitrogen	4.48%
Available P. A.	1.34%	Fat	7.60%

Value as a fertilizer $9.00 per dry ton of 2000 pounds.

We believe that we are warranted in the conclusion that all the sludge produced will be taken as a fertilizer, and we shall not be required to establish large areas for its final disposition. This will certainly solve the sludge problem in this vicinity, as there is no waste area about Milwaukee upon which sludges could be deposited, and the only other disposition which could be made of it would be mixing it with ashes and making land projecting into the lake.

There are many details of the activated sludge process to be worked out before final conclusions can be drawn as to the best designs for a treatment plant to fit existing conditions. Many phenomena are appearing in our experiments which are aiding us in the final designs for our ultimate plant in Milwaukee, should this process be finally adopted.

All of our experiments have been made upon raw sewage having a temperature of over 50°F. It is well known that a lower temperature greatly affects the efficiency of nitrifying organisms. At times Milwaukee sewage attains a temperature of 42°F. Until we operate the process through the winter season, we cannot reach such conclusions as would warrant us in adopting the process for this city.

The most economical method of diffusing the air, the proper spacing of the diffusers per square foot of tank surface, the proper depth of liquor, the volume of air in cubic feet per minute per gallon of sewage necessary to maintain activated sludge, best method of dewatering the portion of sludge returned to the running-through chamber, and of dewatering that portion finally recovered from the process, and many other matters of more or less importance, are being studied.

Many experiments have been conducted to ascertain the proper volume and rate of air to be applied. For instance, the fill-and-draw tank has been operated with four fillings per

day as follows: ½ hour filling, 4½ hours aeration at the rate of 65 cubic feet per minute, or 1.37 cubic feet of air per gallon of sewage, ½ hour settlement and 1½ hours drawing (aeration begins when filling begins); also with six fillings per day based on 2½ hours aeration at the rate of 130 cubic feet per minute, or 1.52 cubic feet of air per gallon of sewage treated. In both cases the nitrogen cycle was maintained, which means a stable, clear effluent with over 95% bacterial removal, showing that with 11% more air a reduction of 50% in tank area can be made.

Next to the volume of air applied and length of application, the most important factor appears to be the method of air distribution. This is particularly true of the continuous-flow method. All persons who have observed distribution phenomena in settling tanks of the continuous type have learned that it is almost impossible to devise a tank wherein all units of liquor will be subjected to the same period of detention; currents frequently develop which pass some portion of the liquor from the inlet to outlet in almost a direct line.

For this reason those who have been experimenting with the activated sludge process have been afraid that the continuous-flow method would prove unsuccessful—that some portion of the liquor would be short circuited and receive less than its share of air during the detention period.

Our tests however have shown that this theory is not true, providing the air is well diffused as it comes into contact with the sewage. The diffuser should be capable of breaking the air into minute bubbles; these rise in umbrella shape, creating a downward current of liquor, which, in turn, carries back and diffuses in every direction many of the air bubbles set free from the diffuser. As a result the whole body of the liquor and sludge becomes a swirling mass.

Our experiments carried out on two tanks working side by side, treating equal volumes of sewage drawn from a common feed line, and aerated for equal periods of time with like volumes of air (one tank provided with a Filtros diffuser, and the other with a jet of air passing from the end of a ½-in. pipe 3½ in. above the bottom of the tank, pointing downwards) brought out the following interesting facts:

First, the Filtros diffuser required a little greater air pressure than the air jet, due to frictional loss through the plate.

Second, the air jet agitates the mass of liquor and sludge in the tanks in much the same manner, though less vigorously than the Filtros diffuser.

Third, in both cases excellent purification is effected by the use of sufficient air.

Fourth, the Filtros diffuser purifies the sewage in a shorter time and to a higher standard than the air jet.

After several months' experiments we have so far found the best method of diffusing the air is by passing it through a Filtros plate 1½ in. thick. Filtros is a mixture of quartz sand of uniform efficiency cemented together and burned or baked. It is made by the General Filtration Company of Rochester, New York, and of such density as required under any stated conditions. Perforated pipes have a tendency to discharge the air too freely and in large bubbles, so that the air is wasted and does not mix as intimately with the liquor as the smaller bubbles ejected from the fine pores of the Filtros plate.

So far we have conducted our experiments with a ten-foot depth of liquor in the tank, primarily because this was the maximum depth which could be maintained in the tanks available. We have no reason to believe that deeper tanks would not give as good results, although we do believe there is a limit of depth due to the inability of the standard blower to compress the air economically beyond 10 or 12 pounds pressure; and the blower, in large units, being much more economical than a piston air compressor, we feel that it should be used.

That the continuous-flow method by this process may be thoroughly tried out before designing sewage-treatment works for the City of Milwaukee, we are now constructing, at a cost of $65,000, a plant capable of treating two millions of gallons of sewage per day, based on four hours' aeration, one-half hour sedimentation, with a mixed sludge content of twenty-five per-cent.

There are to be eleven tanks in all, built of concrete, circular in form, 30 feet inside diameter and 13 feet deep. Eight of these are to be used for aerating the liquor as it continuously

flows through them, one for sedimentation and two for sludge accumulation and sludge aeration.

This plant will be completed by November 15, 1915, and will be put in operation promptly thereafter, so as to get well activated sludge before the temperature of the sewage falls below 50°F. Arrangements have been made to take the sewage by gravity from the large intercepting sewer discharging alongside the plant, and the volume taken will fluctuate with the volume carried by the sewer. The volume of air used in the plant will be automatically regulated to the volume of liquor treated throughout the 24 hours of the day, so that each gallon of sewage will get its proper volume of air. This plant will be the first one built to treat sewage by the activated sludge process, and the results obtained should prove interesting to those engaged in designing sewage-treatment works.

COST.

Every engineer and chemist who has visited our experimental station has expressed surprise at the results obtained and the general expression has been "You are producing remarkable results, but what is the cost". In order to determine the cost we have installed the best apparatus obtainable for determining all those elements which go to make it up. Seventeen men are employed at the station, of whom two are chemists, two bacteriologists and three engineers in charge of operation, all under control of the Chief Chemist. Mention is made of this to indicate that more than usual care is being taken to obtain reliable records.

A contract has already been awarded to build a permanent plant capable of treating two millions of gallons per day by the continuous-flow method, which fairly establishes the actual cost of construction. Definite propositions have been secured from leading manufacturers of machinery and plant necessary to produce the required air, and in addition thereto, the cost of delivering electric current for operating air blowers has been secured from the local company supplying same to the City. From this information and from the data secured from the operation of our experimental plant, the following diagrams of cost have been prepared. Figure 1 shows the cost

of compressing air by either steam or electric power and includes all overhead charges except engine-room labor. Figure 2 shows the cost of air per million gallons treated for several periods of aeration and with the various quantities of activated sludge embodied in the liquor while being treated, and at the several volumes of air used in minutes applied per gallons treated. These costs also include all overhead charges except

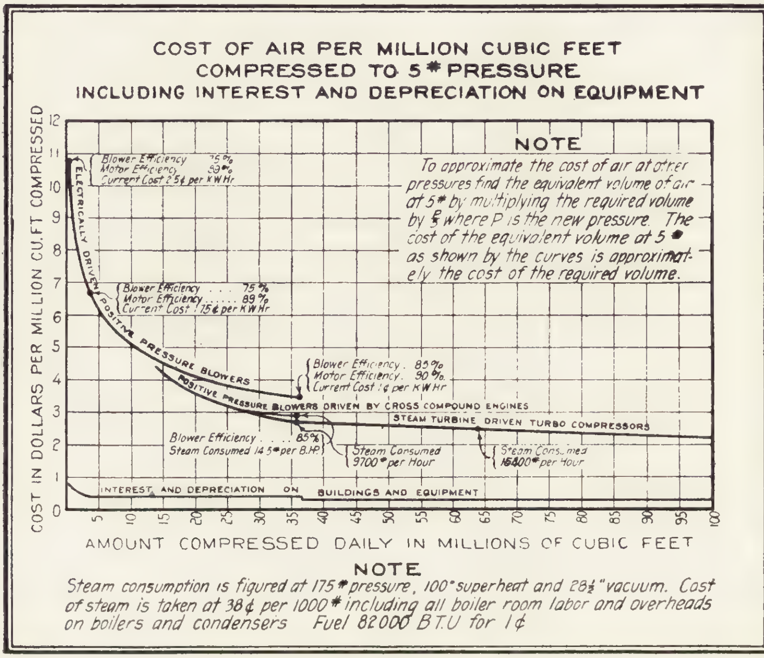

Fig. 1.

engine-room labor. Figure 3 shows the entire cost of the treatment at the several rates of aeration and activated sludge content, and is based upon the cost of tanks exclusive of any special foundations. This cost includes all overhead charges on plant, such as interest, sinking fund, depreciation and boiler-room labor, and excludes engine-room labor, outside plant attendance, chemist and superintendence and disposal of sludge.

The Milwaukee plant will be designed to treat an average of 50 million gallons daily with a maximum load of 75 millions. Assuming 4 hours' aeration and at a rate of 0.25 cubic feet of

TABLE NO. 1.

Fill-and-Draw Tank—Summary of Analytical Data.

Month 1915	Gallons treated per day	Hours of aeration per day	Air cu. ft. per gallon	% of sludge	No. of bacteria per c. c. 37° C	Parts per Million: Sus-pended matter	Total Solids	Oxygen consumed 30 mins. boiling water	Dissolved oxygen	Nitrogen as: Organic	Free Am-monia	Nitrite	Nitrate	Stable for hours	Source of sample
May					120,000	273	980	98		25	10.4	0.21	0.83		Sewage
	54,600	*18.7	1.6	14	14,000	34	730	30		15	10.4	0.54	0.50	91	Effluent
% R					90	88	25	70		40	0	–157	40		
June					149,700	252	1100	123	0.92	27	12.1	0.49	1.18		Sewage
	51,120	†19 2	1.4	14	7,400	8	760	29	9.00	13	10.0	2.68	2.86	69	Effluent
% R					95	97	31	76	–880	54	17	–450	–142		
July					430,000	260	1030	107	0.25	92	15.3	0.178	0.13		Sewage
	55,220	‡19.0	1.84	20	7,180	3	760	22	5.53	30	5.8	1.134	5.47	110	Effluent
% R					98	99	26	79	–211	67	63	–532	–411		

* Average period of aeration = 4.01 hours per charge of sewage.
† " " " " = 4.45 " " " " "
‡ " " " " = 4.23 " " " " "

Note: The — sign signifies an increase in dissolved oxygen, nitrite and nitrate.

TABLE NO. 2.

Data Showing the Effect of Applying Air at Rates Varying From 1.3 to 3.2 Cu. Feet per Gallon of Sewage.

No. cu. ft. of air per: Gal. of sewage	Min.	Time of aeration: Hr.	Min.	Sewage applied	No. of bacteria per c. c. which grow at 37° C. in settled effluent after aeration for: ¾ hrs.	1¾ hrs.	2¾ hrs.	3¾ hrs.	4¾ hrs.	Sewage: Free Ammonia	Nitrite	Nitrate	Parts per Million. Settled effluent after aeration for: ¾ hr.: Free Ammonia	Nitrite	Nitrate	1¾ hrs.: Free Ammonia	Nitrite	Nitrate	2¾ hrs.: Free Ammonia	Nitrite	Nitrate	3¾ hrs.: Free Ammonia	Nitrite	Nitrate	4¾ hrs.: Free Ammonia	Nitrite	Nitrate
1.5	75	5	2	110,000	6000	6000	5000	1000	1000	8.1	.85	0.60	9.6	.38	0.70	10.1	0.43	0.8	10.1	0.43	0.8	10.1	0.43	0.7	10.1	0.43	0.7
1.3	75	4	48	250,000	72000	40000	30000	18900	9200	16.2	.52	1.00	18.7	.90	0.00	21.2	0.00	0.0	20.2	0.00	0.0	19.2	0.00	0.0	19.2	0.00	0.0
1.4	75	4	50	300,000	23000	15000	9000	3000	2000	16.1	.22	0.08	13.1	.00	0.00	14.1	0.60	0.0	13.0	0.70	0.45	12.6	0.85	1.6	11.1	1.05	3.16
2.9	150	4	49	490,000	75000	23000	10000	2000	1000	22.7	.08	0.08	16.7	.00	0.04	16.2	0.60	0.3	13.1	1.15	1.80	11.1	1.75	4.2	8.1	2.00	6.60
3.0	150	5	0	280,000	133000	53000	23000	14000	6300	21.7	.08	0.08	16.7	.00	0.04	14.6	0.95	0.7	10.6	1.75	2.80	7.1	2.20	5.6	5.1	2.50	8.20
3.2	150	5	20	980,000	100000	29000	11000	10000	1000	19.2	.00	0.12	11.1	.75	3.36	6.1	1.15	4.5	3.1	1.35	8.0	1.0	0.36	11.6	0.0	0.10	12.40

The Following Percentages of Removal Have Been Calculated From the Data Given in the Preceding Table.

Cu. ft. air per gallon of sewage	Bacteria growing at 37° C. after aeration for: ¾ hours	1¾ hours	2¾ hours	3¾ hours	4¾ hours
1.4	85	91	93	96	98
3.0	82	94	97	98	99

air per minute per square foot of tank surface and with an activated sludge content of 25%, the entire cost of treatment will be \$5.30 per million gallons treated. The results of our experimental plant have indicated that the above figures can be materially reduced.

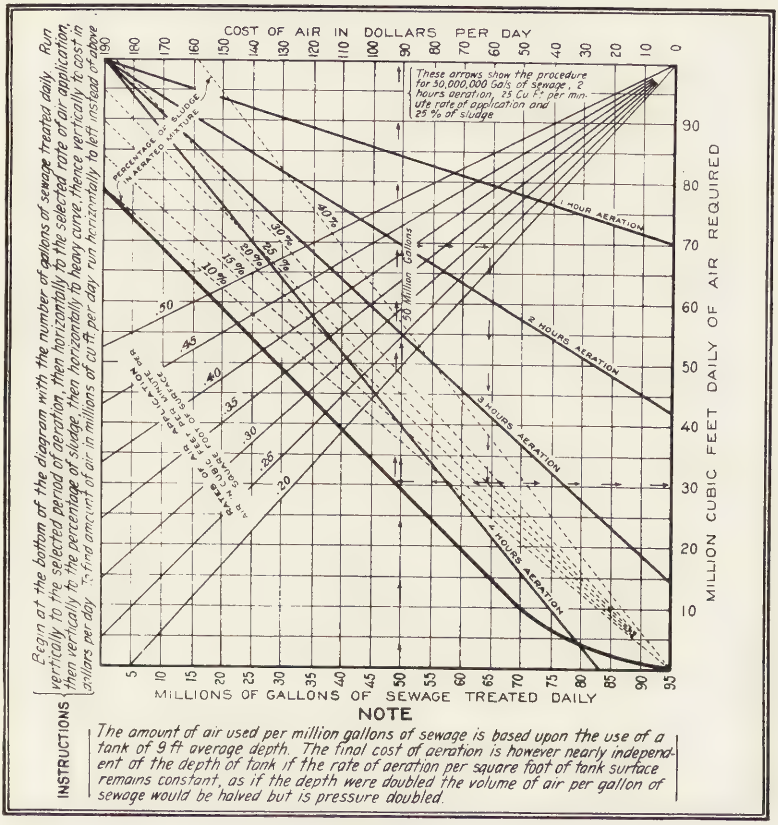

Fig. 2.

Compare this cost with that of securing a good effluent by means of Imhoff tank and sprinkling filters with 6 feet depth of stone, as in the plant at Atlanta, Ga., which might be cited as representing one of the best constructed and operated plants in the United States of which reliable data are available. Mr. Charles C. Hommon, Chemist-in-Charge of this plant, states, in his article in Engineering Record, July 3, 1915, page 4, that he

has been securing very excellent results at a rate of two millions of gallons per acre of filter area, with 6 feet depth of stone.

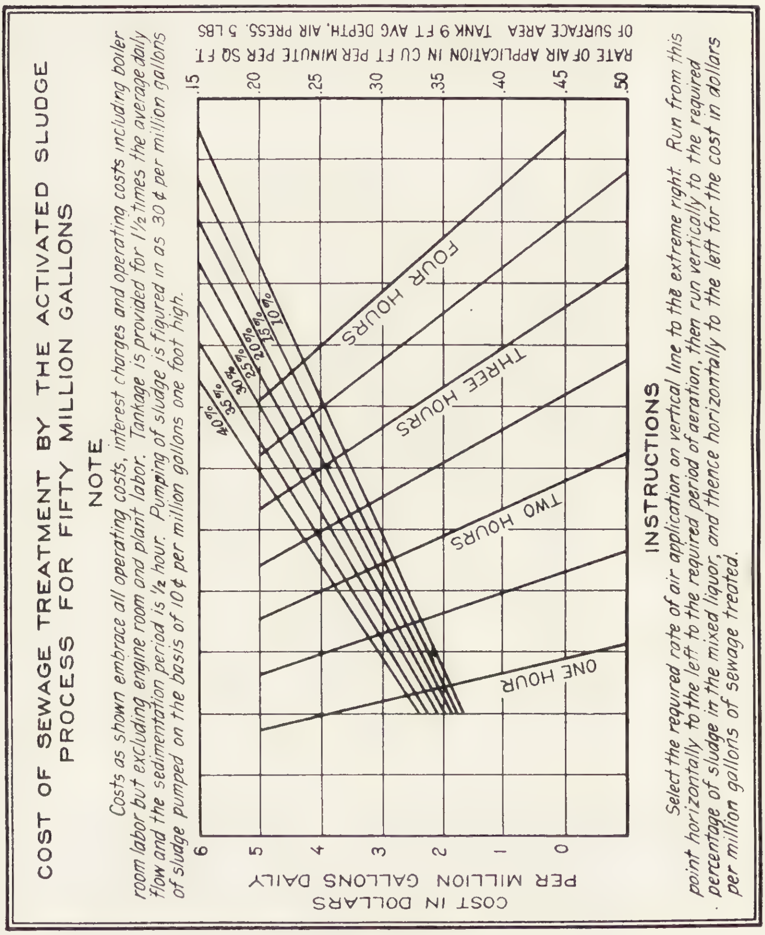

Fig. 3.

From careful estimates made in our office of the cost of constructing continuous-flow tanks for the activated sludge process, including sedimentation and sludge tanks, and based upon four hours' aeration with 0.25 cubic feet per minute per square feet tank surface and 25% sludge content, and Imhoff tanks 26.5 feet deep based upon a 2.5-hour running-through

period, there was no difference in the cost. Thus the cost of the Atlanta Imhoff tanks may be offset by the cost of the continuous-flow tanks.

In order to secure the results at Atlanta, sprinkling filters and final sedimentation tanks are necessary; therefore, the overhead charges for these should be compared with the cost of air in the activated sludge process.

An average cost of sprinkling filters and final sedimentation is \$40,000 per acre. This, at the Atlanta rate, is \$20,000 per million gallons. Interest, sinking fund and depreciation charges based upon 8% of this cost amount to \$4.40 per million gallons. This is the cost which must be offset by the cost of the air in comparing these two processes.

When treating 50 million gallons under the conditions above specified the cost of the air will be, as shown upon Fig. 2, \$150.00 per day, or \$3.00 per million gallons, making the activated sludge process about 32% less than the Imhoff-tank and sprinkling-filter process.

Aside from this is the loss of at least 12 feet head which must be considered in the latter process. Under ordinary conditions loss of head means either pumping or increased size or length of outfall sewers. With the activated sludge process it might be economically used, if available, by hydraulically compressing the air, thus cutting down the cost of the process.

As a matter of general interest, data obtained by the analysis of the sewage before and after treatment by the two methods are given in the following table:

Table No. 1 shows the average analytical data secured from the draw-and-fill method during the months of May, June and July. It must be borne in mind that we have followed the policy of making tests, throughout the period covered by this, and the following tables contain data obtained under various conditions as to volume of air applied and the period of application.

Table No. 2 shows the effect of applying air at different rates and for different periods.

The reason for aerating 4½ hours instead of a 4-hour period is that the air is turned on when the filling begins. This insures the Filtros plate being blown free of settled sludge,

which is not the case when six feet extra head of liquor is put upon it. By this method the last part of the liquor run into the tank gets but 4 hours' aeration.

CONCLUSIONS.

Our experiments so far conducted warrant us in reaching the following general conclusions:

The standard of effluent secured is directly proportional to the volume of air applied per gallon of sewage treated, based upon the suspended matters in and the oxygen consumed by the raw sewage.

The cost of the process depends largely upon compressing and applying the required air economically.

To secure the most economical distribution of air, some type of diffuser must be used which will break up the air into small bubbles and with the least loss of frictional head through the diffuser.

Air applied by jets, orifices or other like devices is too costly, in that it fails to scrub the liquor as effectually as when applied through a diffuser.

For economic reasons, the air applied should be secured by a blower of the positive type rather than by a compressor of the piston type. This limits the maximum depth of aerating chambers to 23 feet.

The proper depth of aerating tanks depends upon local conditions, but should not be over 23 feet nor less than 8 feet. A less depth fails to utilize advantageously the full effect of the applied air.

The aerating tanks should be long and narrow, limited to probably 8 feet in width.

The proportion of air diffuser surface to tank surface should not exceed 1 to 10, preferably 1 to 8.

Maximum period of sedimentation required is 30 minutes. The top four inches of liquor in the sedimentation chamber is free of suspended matters in 10 minutes.

A mixture of 25% of activated sludge with the sewage being treated in the aerating chamber appears to be the most economical volume to secure a stable and clear effluent.

With the above mixture, a stable effluent can be obtained

by the "fill-and-draw" method by using 1.69 cubic feet of air per gallon of sewage treated, applied for two hours.

With the above mixture, a stable effluent can be obtained by the "continous-flow" method by using 1.77 cubic feet of air per minute continuously applied per gallon of sewage treated.

Good activated sludge, of the volume named, must be constantly maintained in the aerating chamber to secure stable effluent. This can be done by returning the sludge precipitated in the settling tank to the aerating-tank effluent by any convenient means.

A good bacterial removal, clear effluent and a reduction of 95% suspended matters can be obtained by maintaining a 12% mixture of activated sludge in the aerating chamber and without maintaining the nitrogen cycle, but the effluent will not be stable for 5 days.

The value in the sludge can be easily recovered and the sludge disposed of at a profit.

The process is applicable to the treatment of all characters of sewage met with in the ordinary industrial community. Its operation is easily controlled and the character of effluent can be determined by simple tests quickly made.

The process can treat a peak load without extra tankage capacity by the application of additional air.

It is a complete process within itself, and requires no auxiliaries aside from those necessary to handle the sludge.

It is entirely free from odor and the resultant sludge is inoffensive either in odor or appearance.

When the temperature of the Milwaukee sewage is 50°F., or over, it can be more economically treated by the activated sludge process (considering the character of effluent obtained) than by any other process of sewage treatment studied at the Milwaukee testing station.

This conclusion is true either with the "fill-and-draw" or "continuous-flow" method.

Paper No. 58

SEWERAGE FOR LOW COUNTRIES, WITH SPECIAL REGARD TO THE TOWN OF AMSTERDAM.

By

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Amsterdam, The Netherlands

The low-lying countries referred to in this article lie below the average high-water level of the sea; hence, mechanical appliances are required to remove the superfluous water. These conditions prevail in the richest and most important parts of the Netherlands. This practically flat country is intersected by ditches in which the water-level must be kept as near as possible at a level which is fixed for every special district. Too low or too high a water-level might be the cause of serious damage.

Though a low water-level is desirable for low-lying meadows, hayfields and protecting dikes, too low a water-level would endanger the safety of navigation, the safety of foundation piles and the possibility of providing drinking water for cattle. The difference which may be allowed varies between a few decimeters only.

All rain-water has to be pumped off from lands the average level of which is lower than the average low-water level of the sea. This requires approximately 0.012 water-hp. per meter lift when the canals and ditches are kept in proper condition.

In case the "polder" has not been used for building area, the total area of the ditches should be 3% of the total area of the "polder". Should it, however, be used for building purposes, then either the capacity of the pumping engines or the capacity for storing rain-water must be increased accordingly.

More storage room for water may be obtained either by the digging of canals, lakes or ponds, or by raising the streets if the

town is newly laid out. The latter method, however, must generally lead to higher building expenses, as the timber foundation piles have always to be kept under the ground-water level.

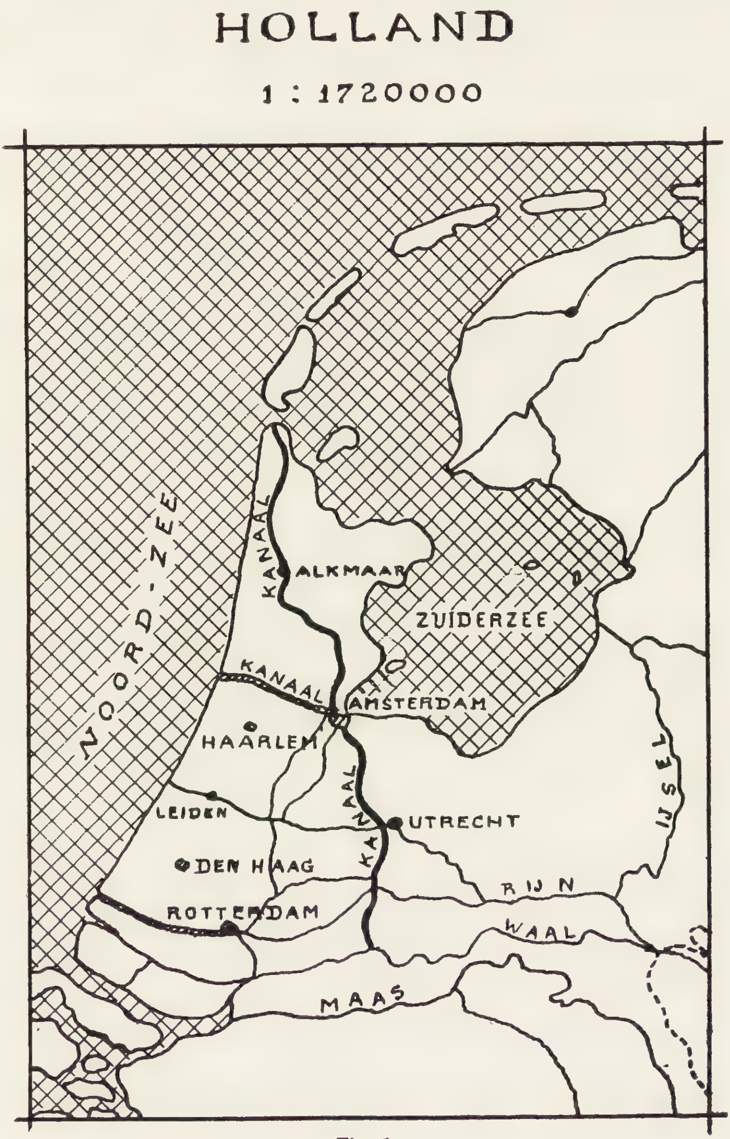

Fig. 1.

For a town built in a "polder" in the Netherlands, the following figures may be taken as desirable:

Streets	25%	of area of town.
Parks, squares, burial places, etc.	15%	" " " "
Canals	10%	" " " "
Houses	25%	" " " "
Gardens	25%	" " " "

0.05 water-hp. per hectare per meter lift will suffice for the discharge of rain-water when the streets are laid 1.5 to 2 meters above the normal water-level.

BOEZEM AND POLDER TOWNS.

From these low-lying lands ("polders"), the water is pumped into a system of canals or lakes, called the "boezem", which discharge daily into the sea, or into tidal rivers.

As in some cases lakes which formerly were part of the "boezem" have been reclaimed, the area of the "boezem" was reduced and the necessity arose to keep on pumping constantly, even under trying circumstances, as when westerly winds prevail, which are generally accompanied by heavy rains.

As nearly all the old Netherland towns are built near rivers or canals, they discharged the rain-water into these canals or rivers, that is, into the "boezem". When these towns became of greater importance they were intersected by canals for transportation purposes, on the banks of which houses and warehouses were built. The water-level in these canals was kept level with the water-level in the "boezem", which did not add to the cost of construction, as the earth obtained by the digging of the canal was used for raising its embankments. The rain-water could be got rid of by discharging it into the canals.

When, however, in the second half of the nineteenth century town extension caused the canals to lose much of their importance as means of transportation, and as the cost of filling up large areas of low-lying lands in the "polder" added not inconsiderably to the cost of building, the question arose either to keep the water-level in the canals lower than the water-level of the surrounding "boezem", pumping out the water by mechanical appliances, or to keep the water-level in the canals level with

the water-level in the "boezem", which latter course, however, necessitated the filling up of the low-lying "polder".

Rotterdam has adopted the former system for its extensions; Amsterdam follows the latter course. Should, however, the borough of Watergraafsmeer be added to the town, then the "polder" system will have to be maintained, as the ground is so much lower than the level on which Amsterdam is built that the filling in of the polder to this height would be impractical.

The decision as to which system to adopt is mainly a question of expense.

In order to provide storage room for rain-water, a polder town has to be more spacious and greater pumping capacity of the engines is required, but a great saving is obtained by not having to fill up the polder with sand.

SEWERAGE AT AMSTERDAM.

The "old town", within the old moat, discharges its rain and waste water and its sewage into the canals which intersect the town. The water in these canals is renewed every night by admitting at high tide water from the Zuider-Zee at one end of the town and letting it out at the other end into the North Sea Canal. In some instances the water is pumped out and is replaced by water from the river Amstel.

The water let into the town is directed through the different canals by a system of sluices or locks. When water is let in from the Zuider-Zee, the river Amstel is entirely isolated by locks, so as to prevent the brackish Zuider-Zee water from mixing with its water, as this would make it unfit for agricultural purposes and for cattle.

The new town built after 1870 outside the old moat, mostly in other boroughs, discharged its rain- and waste-water into the canals; its sewage, however, was removed by means of the Liernur system, that is, a system by which the sewage is collected into cesspits and tanks by means of a system of pipes in which a vacuum was created by means of air pumps placed in a central station.

This system proved to be technically practical, but economically a failure. The practical result being that after the ammonia had been extracted for the making of hydro-sulphide

of ammonia, the sediments were thrown into one of the canals and found their way back into the other canals of the old town.

Notwithstanding in forty years the number of inhabitants doubled, nearly all the polluted water of the town was led into the canals, with the result that these emit a most offensive smell in summertime, to the great annoyance of the inhabitants, though not affecting their health, as the death rate has decreased by one half during that period.

In 1907 the municipal authorities decided to build a new system of sewerage in the new town and in part of the old town. This system was chiefly designed by my predecessor, Mr. J. van Hasselt, and will probably, as far as the new town is concerned, be completed in 1916. This plan provides for a town extension of 1000 hectares, with 600 inhabitants per hectare.

SLUICING SYSTEM.

To carry off sewage, the combined sluicing system was adopted as the cheapest.

The choice was not difficult, for most of the houses are arranged for this system, whereas, the alterations required for a double system were estimated at fl. 1.400.000 ($563,000). Besides, the district sewers which have to carry off the water of violent showers, had only to be increased by 5% in order to discharge at the same time the waste-water from the houses, which of course was much cheaper than the construction of a second system of sewer pipes.

The advantage, that in case of rain the water discharged contains much sewage which is carried off, is balanced by the disadvantage, that in case of continued rainfall more or less polluted water flows into the canals at the emergency overflows. According to a calculation made in the wet year, 1903, this quantity would be no more than 3% of the total amount discharged.

The working expenses of the combined system are not higher than those of the double system. It is true that the quantity of water which has to be pumped up is about 10% greater, but this water washes the sewers out properly, which, otherwise, would have to be done by admitting water. At the

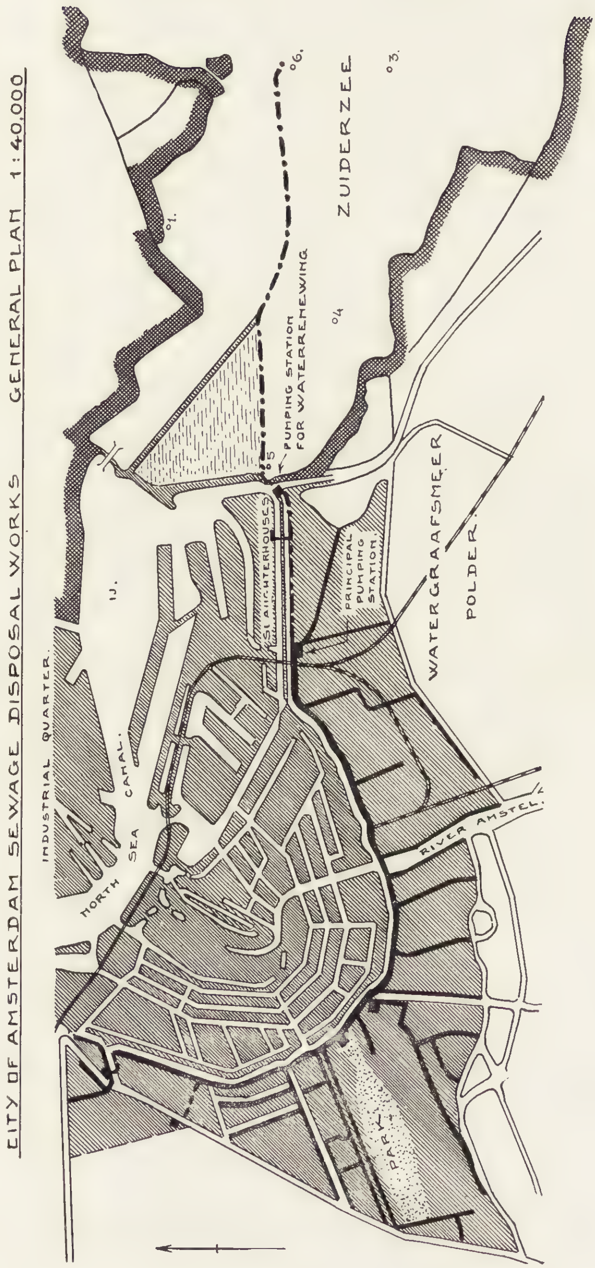
CITY OF AMSTERDAM SEWAGE DISPOSAL WORKS GENERAL PLAN 1:40,000
ZUIDERZEE
PUMPING STATION FOR WATERRENEWING
SLAUGHTERHOUSES
PRINCIPAL PUMPING STATION
WATERGRAAFSMEER POLDER
IJ.
INDUSTRIAL QUARTER
NORTH SEA CANAL
RIVER AMSTEL
PARK

Fig. 2.

same time, the expense of keeping in repair a second set of pipes in the soft Netherlands soil will be avoided.

GENERAL PLAN.

The sewerage system consists of a main sewer around the old moat, into which empty a number of secondary sewers, each draining a district. The street sewers empty into these

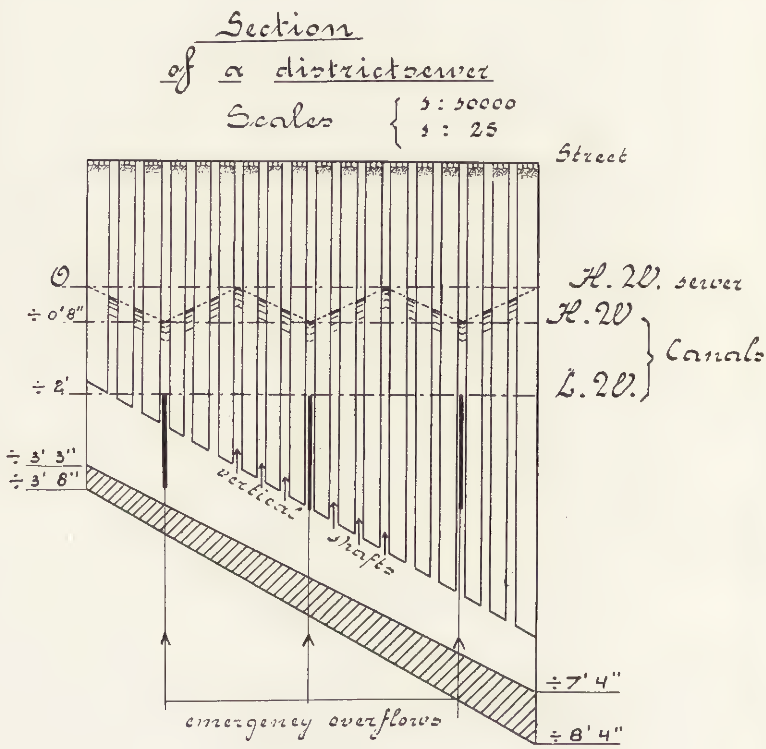

Fig. 3.

secondary sewers. The houses, generally four stories high, discharge their water by means of pipes 0.125 m. diameter into brick cess-pits, which are found in the sewers at distances apart of about 24 m. The gutter-sinks also empty into these cess-pits. The following may seem strange:

The drains in the houses, which up to a few years ago were connected with the Liernur system, have very deep siphon

bends—sometimes several consecutive ones—in order to prevent the vacuum from decreasing too rapidly when the water is pumped out. It was feared that these bends, which are sometimes 0.80 m. high in pipes of only 0.125 m. diameter, might cause difficulties, as obstructions could not be removed by vacuum pumping. But no such difficulties have presented themselves; the great quantity of water which remains in the bends seems to be effective in preventing the sewage from settling; at the same time, the great force with which the water comes down from the top floors drives the sediments along.

From every house, the rain-water, waste-water and faeces flow through a single, sloping clay pipe to the cess-pit, and thence into the system of street sewers. The latter are clay pipes, 0.38 m. diam., caulked with loam; they are placed horizontally, with the bottom 0.05 m. below the normal level of the canals. They gradually sink into the soft soil, so that in the end most of them lie below the level of ground-water and leak at the joints.

The advantage is that the pipes are always covered with water, hardly ever get quite clogged and, at the same time, regulate the level of the ground-water; but the irregular sinking causes much sand to collect in the deeper parts. It really is astonishing that such a system has been able to discharge the water.

In order to make the water flow so rapidly that the sewage is carried along, the street sewers must not be too long; so a great number of district sewers were made deep enough to enable the street sewers to empty into them, except with a very heavy rainfall.

It would be advisable to give the street sewers a slope toward the district sewers, but then they would have to be constructed on piles so as to prevent a lowering of the ground-water level and the consequent decaying of the wooden foundations of the buildings.

The district sewers are oval pipes, with water-tight joints, resting on piles. They are made of cement-concrete mixed with trass in order to prevent the influence of the acids in the soil. The composition of the concrete is 1 part cement, 1 part sand, ½ part trass and 2 parts gravel. The sewers can discharge

1.05 liters of waste-water plus 22.25 liters of rain-water = about 24 liters per second per hectare. The amount of 22.25 liters corresponds to a rainfall of 20 mm. per hour, which is hardly ever surpassed. It is assumed that the sewers have to carry off 90% of the rain-water from the roofs, 60% of that from the streets, and 18% of that from the gardens. It is also assumed that 4/9 of the surface from which water is collected is roof area, 1/3 street area and 2/9 garden area. Besides, it is assumed

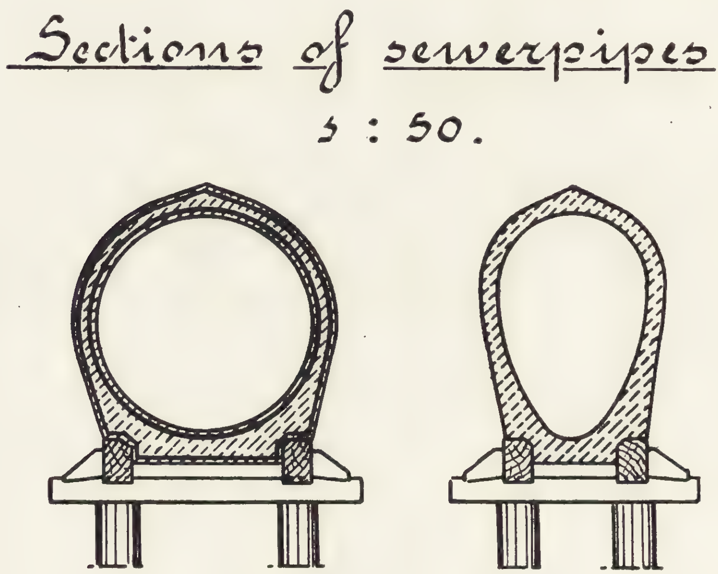

Fig. 4.

that the delay in run-off causes only about 5/8 of the quantity falling to be carried off at once.

The calculation is then: 4/9 x 0.90 + 1/3 x 0.60 + 2/9 x 0.18 =0.64; 0.64 x 5/8 x 0.020 x 10,000* = 80 cub. m. per hour = 22.22 litres per second.

When the main sewer cannot discharge all of the water, the emergency overflows open and the surplus water is discharged into the canals. In unfavourable circumstances, however, the fall of the secondary sewers will not be more than 0.20 m., owing to the low level of some gardens and the rise of

* 1 hectare equals 10,000 square meters.

Section of a trench for mainpipe

1:60.

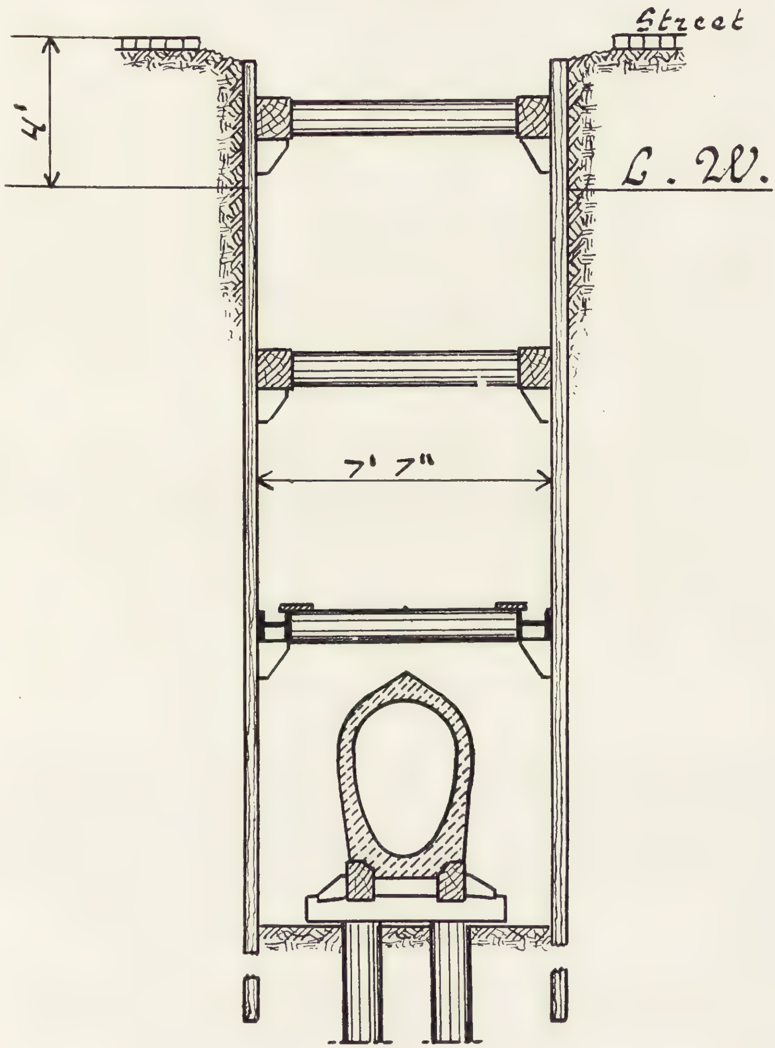

Fig. 5.

the water-level in the canals when the discharge of water through the North Sea Canal is impeded.

Owing to the small fall, a great number of emergency overflows (55) had to be made; otherwise the dimensions of the sewers would have had to be increased. No harm was seen in this, as in case of heavy rainfall only clean water overflows into the canals. The emergency overflows have, by preference, been made opposite the spot where the district sewer empties into the main one.

In the case of the dry-weather sewage flow, that is, when the emergency overflows do not work, the district sewers usually

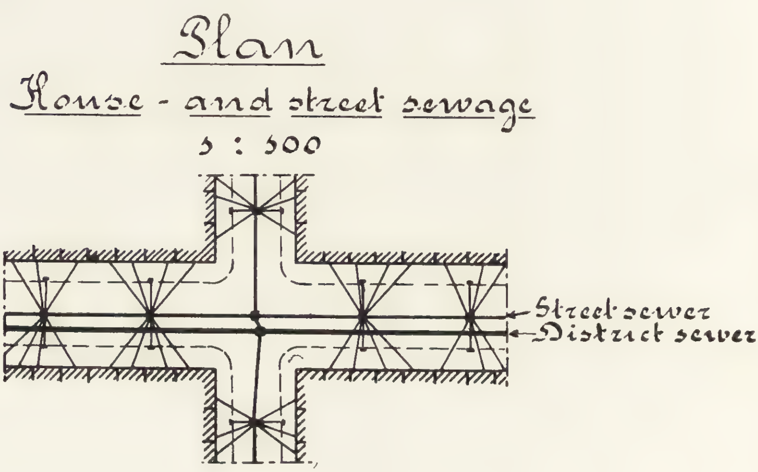

Fig. 6.

present a gradient of 1 in 1000. This produces a velocity of from 0.34 to 0.85 m. per second when the discharge in the main sewer is 1750 litres per second. This is the capacity of the main sewer, calculated at 700 liters of rain-water and 1050 litres of waste-water from the houses. The latter amount is found by assuming 6.25 liters per inhabitant and 600 inhabitants per hectare.

The main sewer is likewise made of cement-concrete mixed with trass, the pipes having water-tight joints. Only the largest ones are round and reinforced, the others are oval. They are all supported on a foundation of piles.

The gradient is from 1 in 1000 to 1 in 2500; the calculated velocity varies between 0.47 and 1 m. per second. The whole length of the sewer, about 6500 m., is divided into two almost equal parts. The western part will be pumped into the eastern one. The intention is to install centrifugal pumps with horizontal shafts: two pumps with a capacity of 400 liters per second and two with a capacity of 800 liters per second, half of which may be considered as reserve pumps.

The principal pumping station has centrifugal pumps with vertical shafts; two pumps of 600 liters per second capacity and 485 revolutions per minute, and two pumps of 1200 liters per second capacity and 360 revolutions per minute, half of them being reserve pumps.

Moreover a number of small automatic engines have been designed, which pump the water from the islands or from low-lying parts of the town into the sewers. At the points where the sewers cross the River Amstel and the canals, iron siphons have been constructed.

All the pumps are worked by the municipal Central Electric Station, and so far they have given great satisfaction. The pumps of the principal pumping station work well on an efficiency of 60%; the cost per cubic meter of water pumped is less than 0.1 cent. With the exception of the floating sewage removed from the screens and the sand deposited in the cellars near the pumping station, nearly all the sewage is carried along by the pumps.

WATER DISCHARGE.

The discharge of the sewer water is a difficult problem for Amsterdam.

Whereas, at Rotterdam the Meuse at ebb-tide carries off the polluted water, which is only 0.1% of the river water, and the Hague discharges its water straight into the North Sea, Amsterdam can dispose of its sewage only into the Zuider-Zee, an inland sea, the North Sea being too far distant from the town.

It is to be regretted that the sewage discharge must take place at one end of that inland sea, where there can be practically no other current than that caused by the difference between high and low water—usually only 0.54 m.

The government has permitted this discharge only on the condition that the water shall be purified if its pollution should cause inconvenience. The place of discharge has been chosen at the end of a dam, on which the sewer could be placed without requiring a wooden foundation, and as far as possible out at sea, because the sea water used to cleanse the canals is taken from the same inland sea into which the sewage is discharged.

The discharge sewer is a delivery pipe of a length of 5700 m., 4000 m. of which reaches into the Zuider-Zee; it is made of reinforced concrete rings of 1.50 m. diameter, except the two siphons under the Rhine Canal, which are made of steel and are 1 m. diameter. The conduit was made to withstand a pressure of two atmospheres, though the highest weekly pressure has, so far, not exceeded 12 meters. It consists of doubly-reinforced concrete pipes 3 m. long with interstices of 0.05 m., over which lie loose sleeves of the same material 0.50 m. long. The joints were caulked for one out of every 8 pipes with 9 parts asphalt and 1 part bitumen, and for the others, with 1 part cement and two parts sand.

The water from the slaughter house is forced into the delivery pipe by an automatic pump, as this was cheaper than the construction of a conduit to the cellar of the pump station.

At the highest points of the delivery pipe are placed ventilators, which open at 1/50 atmosphere excess pressure. When the conduit is entirely filled with water, the air outlets close automatically.

The delivery pipe between the pumping station and the sea part of the dike has remained watertight, because that part lies in the body of an old, firm clay dike. In the latter part, however, the temperature is subject to great variations and the dam on which the conduit rests is continually giving way, and here the joints have not remained entirely watertight; this, however, causes but little inconvenience. On the other hand, the conduit has shown itself proof against storms, drifting ice, seawater, etc.

In order to withstand the influence of sea water, the pipes were made a long time before they had to be used; the joints were well plugged when delivered, and trass has been mixed in the cement, the composition for these pipes being 1 cement

$+ \frac{1}{2}$ trass $+$ 1 sand $+$ 2 gravel, and for the other pipes, 1 cement $+ 1\frac{1}{2}$ sand $+$ 2 gravel.

PROVISIONAL RESULTS.

Now that this sewerage system has worked for a year,* with about 250 hectares discharging into it, the improvement in the canals of the eastern part of the town is already apparent, and there is no indication of a pollution of the Zuider-Zee. The improvement is evident when we consider that the normal daily fluctuation between ebb and flood in the space south of the sewer outlet displaces a volume of water one hundred times as large as the quantity of sewage discharge; besides, after every storm the water in this part of the sea is absolutely renewed. So it may be expected that the natural purification of the large expanse of water into which the sewage empties will be sufficient.

As for the centre of the town, there remains the question whether it will be possible to cleanse the canals sufficiently without a system of sewerage in the old town.

In 1912, the quantity of waste water from the houses was diluted about seven times by the water admitted to cleanse the canals; but in the future the dilution will be about thirty fold, so that we may expect that in the old town, also, the condition of the water will improve greatly; the more so as this part of the town is no longer a residential quarter but is more and more used for offices and shops.

If necessary, this part of the town will also be connected with the sewerage system. The cost, however, will be very great, owing to the many siphons and to the introduction of intermediate pumps which the canals will necessitate.

A former proposal, to fill up canals for this purpose, would not find supporters now, because experience has taught that this greatly impairs the typical beauty of the town.

When the crescent-shaped town continues to extend on the outskirts, a new main sewer will probably have to be constructed about parallel with the existing one; besides, a pumping station will be installed on the Zuider-Zee dike.

Whether the Zuider-Zee will be able to purify all that pol-

* Dec., 1914.

luted water remains a question, the answering of which we prefer to postpone till other towns in less favourable conditions have found a system to purify the water effectually with little cost.

Such is also the case with the growing factory town north of the North Sea Canal. So far, its polluted water could be discharged into that canal, but provision will have to be made for the purification of the water when that part of the town becomes larger.

For the sake of the ocean-going vessels, the level of the North Sea Canal is, if possible, not lowered below a certain level; for the sake of river vessels it is not raised above that level, as the town locks would have to be closed then. So the water may give the impression of being stagnant; yet the displacement of water is very great, because the North Sea Canal is the "boezem" for the surrounding polders, and every night Zuider-Zee water is admitted into it by means of the Amsterdam Canals.

Thus, in 1913 the quantity of water discharged through the locks was seventy times as great as that which flowed through the sewers of the old town. So, for the disposal of sewage, Amsterdam does not depend exclusively on natural purification. Experience will have to show whether the displacement of water in the Zuider-Zee will be sufficient for the new town and for the North Sea Canal.

We have a few data to go by:

Formerly about 90% of the rain- and waste-water and of the faeces were discharged into the Zuider-Zee; the rest into the North Sea Canal. To the east of the points of discharge, this has caused no inconvenience; to the west, only a little; though the sewage flows very slowly into the North Sea, into which it is discharged at ebb-tide.

At present, about 25% is emptied into the Zuider-Zee. The natural purification is distinctly visible there; the polluted water, being less heavy than sea water, floats on the top like a gigantic grease spot. Only in the centre of the spot, near the mouth of the delivery pipe, on a relatively small area is the odor of sewage apparent; but further on, sun and wind have already exercised their purifying influence, so that this is no longer noticeable.

Once a month the composition of the water is examined at the six places indicated on the map. This examination was already begun three years before the sewerage system began to be worked. So far no important lasting deviations have been found.

COSTS.

As the sewerage works are not yet completed and are only partially worked, the financial results cannot be exactly estimated.

The following sums should be considered as rough estimates of the cost of a sewerage system in a newly founded polder-town, exclusive of purification of the water:

Cost of construction per hectare:

a.	Horizontal street sewers	f 5.000.-
b.	Main sewer, secondary sewers, pumping station and delivery pipe	f 5.000.-
		f 10.000.-

Working expenses per hectare per year:

1	5% interest on a and b	f 500.-
2	Repairs, renewals and cleaning of the works, sub a	f 200.-
3	The same, sub b, electric current	f 200.-
		f 900.-

This amounts to f 1.50 per inhabitant per year and to f 6.75 for an average family—less than 5% of the rent for the cheapest workman's dwelling.

The same proportion between the cost of water discharge and of rent may be assumed as normal in houseless polders; so that the gradual change of a polder into a town causes an increase in sewerage expenses about equal to the increase in value of the land.

When the sewage has to be purified mechanically, the cost will be much greater; but we may hope that the abundance of water so often feared as an enemy will, in this case, prove to be our best friend.

Paper No. 59

STREETS.

By

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INTRODUCTORY.

Public streets are to a city what the veins and arteries are to an individual—they provide for its circulation, and it is extremely important to all cities how their streets are laid out and improved and how maintained. Their location and condition make more of an impression upon the casual visitor than does probably any other physical thing in connection with the city, as naturally it is the one thing with which he is most connected.

The location of streets will be considered in another paper, and therefore will not be touched upon here.

The provinces of streets are to furnish light and air to the occupants and to provide proper means for intraurban traffic. As regards light and air, it makes no difference how the width of the street is treated, but as regards traffic it is very material.

LIGHT AND AIR.

What the width of a street should be to furnish light and air depends upon the character of the buildings that are erected upon it, and upon their height. If the street is in a residential section, where the houses are detached and built on good sized lots, sufficient light and air will be provided, no matter what the width of the street may be. If, on the contrary, the street is in a business section, where every foot of frontage is covered with buildings and where these buildings are high, the width of the street is an important consideration as regards both light and air.

Just what the relation of the width of the street to the height of buildings should be is an open question, and ordinances regulating this vary according to the ideas of the different officials; but, unless conditions specially require it, the height of a building should not be greater than the width of the street, except that when the height is greater, the front of the building should be set back a certain distance so that sufficient light and air may be furnished to the higher stories.

TRAFFIC.

When traffic is taken into consideration, however, different principles prevail. In the first place, the width of the street must be subdivided into roadway and sidewalks, and just what shall be the relative proportions of these widths must be determined by circumstances. Different cities have different rules. An ordinance recently passed by the Board of Estimate and Apportionment, New York City, provides that the sidewalks and roadways for streets of different widths shall be as follows:

Width of Street	Width of Roadway		
	Not Occupied by Railroad	Single-Track Railroad	Double-Track Railroad
Less than 20′	Width of street, less space occupied by curb	Roadway occupied by a Single Track Railroad to be not less than 30 feet	Roadway occupied by a Double-Track Railroad to be not less than 40 feet
From 20′ to 50′	60 per cent		
Not less than 50′ and not more than 60′	30 feet		
More than 60′ and not more than 66′ 8″	One-half street		
Over 66′ 8″	80 per cent, less 20 feet		

This ordinance is not absolute, that is, it can be varied at any time according to the demands of any particular street, and is so varied whenever occasion requires.

As a general proposition, a street in a wholesale district is not a thoroughfare, and a roadway width that will fill local requirements is ordinarily sufficient. On the other hand, such a street is also little used by pedestrians, so that a wide sidewalk is not necessary; in fact, it is even objectionable, as in most cases goods have to be taken across the sidewalk from the truck to the building or from the building to the truck, and therefore a walk should be no wider than is absolutely necessary. If, then, a minimum width of a wholesale street is taken as 60 feet, the question is to divide this width so that it will be best adapted for the traffic.

But one row of trucks can be loaded in front of any building at one time. Large trucks, in Manhattan, New York City, backed up against the curb occupy 13½ feet. If the opposite side of the roadway be similarly used, 27 feet in all will be blocked to transient travel on the street. If the roadway of the street be made 40 feet wide, there will be an unoccupied space in the centre of 13 feet, which would allow trucks going in opposite directions to pass without any difficulty. It, too, would leave sidewalks 10 feet wide, which would be amply sufficient for pedestrian travel. This reasoning is based on the supposition that there will be no encroachment whatever beyond the building line and that the entire sidewalk space will be free and clear.

On retail business streets different conditions govern, as pedestrian traffic is much greater, compared to vehicular traffic, than on wholesale streets. Fifth avenue, Manhattan, New York City, is without question the greatest retail business street in the country, if not in the world. Its entire width is 100 feet, and this width, in the business part of the borough, until a few years ago was subdivided into two sidewalk spaces of 30 feet each and a roadway of 40 feet. The property owners, however, had been allowed to use the sidewalk space to within 15 feet of the roadway, so that a space of 15 feet on each side was all that was really allowed for pedestrian traffic. In 1909, a movement was begun to widen the roadway and remove the encroachments on the street. The curb was set back 7½ feet on each side and all projections removed beyond 2½ feet from the building line, so that there were obtained a roadway width of

55 feet and a sidewalk space of 20 feet on each side for pedestrians. This provided for three lines of traffic on each side of the street, where before there was room for only two, and 20-ft. sidewalks were provided for pedestrians in place of 15-ft. sidewalks. This improvement has been carried out from 26th street to 58th street, which is the larger part of the business section of the street.

On residential streets the questions that have been discussed are determined more by sentimental than by utilitarian principles, as a great deal depends upon whether the lots are built up solidly, as in our cities, or whether the houses are detached. Where they are built up solidly, the rule in force in the city of New York at the present time, giving a roadway width of 30 feet and sidewalk spaces of 15 feet for a 60-ft. street, is probably as satisfactory as can be obtained. In outlying sections, however, where the houses are detached, it is possible to reduce the roadway to 24 feet where traffic is only local, and the width of the sidewalk itself can be a smaller portion of the sidewalk space, that is, 6 or 8 feet wide, according to the requirements of the street; the remaining space can be sodded and allowed for the planting of trees or shrubs. If car tracks exist on the street, however, the principles governing are different, and probably the arbitrary ruling of the Board of Estimate and Apportionment, New York City, providing for a 40-ft. roadway, is satisfactory. If a street is so narrow that it will not admit of a 40-ft. roadway, but one track should be allowed on the same, with one-way traffic, the return traffic being provided for on an adjacent street.

A striking example of special treatment is shown in the case of Queens Boulevard, Borough of Queens, New York City. This boulevard is 200 feet wide, and extends from the centre of Long Island City southeasterly towards the Rockaways. It is proposed to provide a space for rapid transit and surface railroads. The arrangement makes provision for a central space 74 feet wide for the use of these roads and for roadways 43 feet wide on each side of this central space, the remaining width of 40 feet being assigned to sidewalk spaces, each to have a width of 20 feet. Another section of the boulevard, where there are no tracks, provides for a central portion 44 feet wide,

with adjoining 30-ft. park spaces on each side, two roadways 28 feet wide, and sidewalks of 20 feet.

GRADES.

The question of grades of streets is extremely important, and great care must be used in establishing them. Maximum and minimum grades should be adopted for general guidance, to be varied only in extreme cases. Before the days of the cable and electric cars, the maximum grade in a street-car street was determined by the ability of the horses to draw a car up a hill. That was, in some cases, decided to be 5 per cent. The advent of the different powers, however, in street-car work has changed this principle, as the trolley cars easily negotiate a 10 per cent grade, and cable cars even steeper ones, but it would seem that 10 per cent is a maximum limit, unless very exceptional conditions are encountered. As a minimum, 0.5 per cent is a good standard, but that can be reduced to 0.25 per cent on special streets and for short distances.

New York City has grades on business streets as high as 6 or 7 per cent, but they are extremely objectionable for vehicular traffic and should be allowed only where necessary. On some streets in the Borough of Manhattan, New York City, there exist grades of 12 and 15 per cent, and one of 18 per cent. In a report made in 1898 a consulting engineer of New York City, in speaking of this question, said: "But the City of New York has apparently adopted a maximum grade for its thoroughfares of 18 per cent."

Duluth has grades of 12.2 per cent; Kansas City, of 16.5 per cent; Pittsburgh, of 17 per cent, and one for an extremely short distance, some time ago, as high as 30 per cent. But probably the city that has the steepest grades in the world is San Francisco, where one street has a grade for about a block of 55.5 per cent, and Kearney st., in the thickly populated section of the city, has a grade of practically 30 per cent; and there are many paved streets in the city with grades that exceed 20 per cent.

Streets with such grades, of course, cannot be used to any extent. An ordinary staircase has an inclination of about 64

per cent, so one can easily understand what these excessive grades mean.

TREATMENT OF ROADWAY.

Having determined upon the width of the roadway and the grade of the street, the next thing to determine is the treatment of the roadway. For hundreds of years pavements have been laid of different materials and many experiments made to determine which made the best pavement. In the making of these experiments, pavements have been laid of asphalt, coal tar, cement, iron, brick, rubber, shells, gravel, iron slag, and even leather, glass and hay; but at the present time the standard pavements are laid with stone blocks, brick, wood blocks, asphalt and other bitumens.

Just what particular material shall be used upon any street is a question to be decided only after careful study and reflection, as one must know not only the requirements of the street itself, its users and those doing business upon it, but the character of the different paving materials. Not enough study has been given in this country to this question, and pavements, as a rule, have been arbitrarily laid of certain materials without any scientific determination. As a general proposition, however, it can be said that for heavy-traffic streets stone is the most desirable material, but brick can be used in localities where stone is not available. Wood, too, will stand heavy traffic to a surprising extent, but it is somewhat slippery. If, however, a noiseless pavement is desired, in front of schools, hospitals or churches, for instance, or even on business streets where a great number of clerks are employed, wood can be used to advantage, the gain on account of its noiselessness offsetting the economic loss of its possible less durability as compared with stone. On a retail-business or a residential street a bituminous, wood block, or brick pavement can be used. Wood is the most expensive of the three, the brick the most noisy, and, in some cases, the asphalt the cheapest. Any one of the three will make a satisfactory pavement, wood probably the most so if the property owners are able to stand the extra expense.

In considering the question of cost of any pavement, how-

ever, the ultimate and not the first cost must be determined upon, as a pavement which is expensive to lay down may be so much easier to keep in repair that in the end it will be the least expensive. Also, it must be remembered that constant repair work, especially in a business street, is exceedingly annoying, both to the traveling public and to the occupants of the adjacent stores, so that a pavement that is kept in repair without much work must be given special consideration for the foregoing reasons.

FOUNDATION.

No matter what the character of the pavement, it is absolutely necessary that it be laid upon a solid foundation. It has generally been accepted by engineers that concrete makes the best foundation, as a general proposition. The materials for it can be obtained at reasonable prices anywhere that pavements are required, and for that reason it is almost always used for pavement foundations. The common practice is to mix the concrete in the proportion of one part of cement to three parts of sand and six parts of broken stone of a size ranging from 2 inches downward. The thickness to which it shall be laid depends upon the character of the traffic on the street, but, as a general proposition, 6 inches has been accepted as the right depth, but in special cases it has been laid 8, or even 10, inches deep.

In the city of Glasgow, Scotland, however, where loads weighing one hundred tons are moved along the streets, the foundations are only 6 inches thick. The mixture, however, is 1:2:4, instead of the 1:3:6 previously given.

STONE BLOCK PAVEMENTS.

In deciding upon the special material for stone-block pavements, both hardness and toughness are to be taken into consideration. If a stone be too hard, it will wear smooth under heavy traffic and, consequently, be slippery. If, however, it be too soft, it will wear quickly and unevenly, soon becoming rough. The ideal stone is one that will wear smoothly and evenly, preserving the original form of the pavement, and, at the same time, be not slippery.

The old practice with stone pavements was to lay the blocks with a joint about ¾-inch wide. This allowed the blocks to wear at the edges, soon becoming round on top under heavy traffic, so that, even when the blocks themselves maintained their position, the pavement was nearly as rough as one of cobblestone. The later practice, however, has been to make the blocks smaller, have them cut better, so that they can be laid with narrow joints, and to fill the joints with cement grout, pitch, or some other enduring material.

If the load that comes on a pavement can be applied vertically, it will have much less effect upon the pavement than if the surface be rough, so that the wheel moves from one place to another with a jar or jolt, rather than rolling smoothly. The more recent stone pavements, laid with a close joint, will, therefore, be much more durable and pleasing than the old, and the extra expense incurred will be justified on account of the character and durability of the pavement.

BRICK PAVEMENTS.

Brick pavements have been used for many years and have come into general use, especially in cities of the Central West. There, stone is scarce, especially of a character suitable for pavements; but, fortunately, the clays in that locality are of such a nature that they can be burned into bricks that are exceedingly durable.

At first, as was natural, many bricks were used that never should have been put into pavements, and, consequently, some of the pavements failed; but, in recent years, the demand for brick has brought the manufacturers to a realization of what could be made of the business if properly carried on, and the result has been the forming of an organization known as the National Paving Brick Manufacturers' Association. For some eight or ten years this organization has been studying the question, having a paid secretary who travels around the country, visiting cities where brick pavements are laid and attending road conventions and engineering meetings where the subject is discussed, with the idea of having not only good bricks used, but of having them laid so as to produce the best possible results.

The method of testing bricks before they are used has been so developed that it is possible to determine in advance of the laying almost exactly how the bricks will act in the pavement.

Bricks are laid upon a cushion of sand placed upon the concrete foundation, rolled or rammed, and the joints filled with either cement grout or some bituminous material. Different people advocate different fillers, but it is safe to say that good results can be obtained with either of the fillers mentioned if proper precaution is taken during construction. The advocates of the cement filler claim that the grout fills the joints completely, and therefore protects the edge of the bricks from undue wear. The advocates of the bituminous filler, while admitting, possibly, the truth of the former claim, state that one of the principal objections to brick pavement is its noisiness, which is obviated to a great extent by the use of a bituminous filler. The claims of both parties are good, and due weight must be given them.

WOOD PAVEMENTS.

Wood has been used as a paving material, both in this country and in Europe, since about 1840. The first pavements were of untreated wood, selected without any regard to its quality, and the blocks were laid in a hasty and unscientific manner. The result, naturally, was that the pavements soon decayed and had to be relaid with different material. The use of wood, however, was not given up, despite many failures, and it was continued, without treatment, until the latter part of the 90's, when blocks treated with creosote oil were laid in Indianapolis. These pavements, although little attention was given to the treatment of the blocks and the character of the oil, were so successful that the practice of laying treated wood pavements extended to the East, and the material was soon accepted as standard.

In 1900, a wood pavement was laid on Tremont street, Boston, opposite the Common, the blocks being treated with a preservative consisting of one-half creosote oil and one-half resin. The wood was long-leaf yellow pine. This pavement at the present time is in good condition, and has had almost no money expended upon it for repair.

In 1902, the first treated wood-block pavement was laid in New York City, in the Borough of Brooklyn, and is now in good condition, although it has had almost no repairs made upon it.

The cost of resin, however, increased so rapidly that in 1909 it was decided, in New York City, to give up its use altogether and use only creosote oil as a preservative. There has been much discussion in different parts of the country as to the exact nature of the oil and how much should be used. These, at the present time, are mooted questions and cannot be discussed in a paper of this length.

Treated wood pavements have been used in Europe for many years, especially in London and Paris, and are considered the most desirable for the busy sections of those cities. Under the heavy bus traffic on the Strand, wood pavement lasted twelve years; under the heavy carriage and bus traffic on the Champs Elysées, Paris, wood pavement lasts about seven years. These two streets, however, have an extremely large amount of traffic.

In the residential streets of our American cities, it seems a moderate estimate to say that if the treatment which the wood blocks receive keeps them from decaying, a wood block pavement should last at least forty years. A portion of a pavement taken up from Clinton avenue, Brooklyn, New York, where it had received a reasonable amount of traffic, had worn but ¼-inch in 10 years; this would allow a wear of 1 inch of the blocks during a life of forty years. In other residential streets wood pavement has been laid 10 years, subject only to the ordinary local traffic, and almost no wear can be discerned.

Blocks are generally laid on a cushion coat, composed of one part of cement and two or three parts of sand, spread upon the concrete base, the idea being to smooth up the surface of the concrete with a material that will be hard when set, so as to give the blocks a firm and solid bearing. The joints are filled with pitch, cement grout, or sand, any one of the three giving satisfactory results; but different engineers prefer different materials.

In Europe the practice is to lay the concrete so smooth that the blocks can be laid directly upon it and get an even bearing. Sometimes the surface of the concrete is covered with pitch, the

blocks being laid directly upon this pitch. The joints of the wood pavements of Europe are generally filled with pitch, although sometimes cement grout is used.

The objections to wood pavement, in general, are that it is expensive, slippery, and expands on account of the swelling of the blocks, and also, when first laid, it exudes a tarry substance upon the street which is exceedingly disagreeable to pedestrians. The consideration of cost depends wholly upon the ability of the people to pay. The question of slipperiness is important upon grades, and on wet or sleety days. The question of the bulging of the pavement can be taken care of by proper expansion joints. The cause of the "bleeding" of the blocks has not been satisfactorily determined, but it is undoubtedly true that in a year or two, at the latest, methods of treatment will be devised by which this will be overcome.

The advantages of wood pavement are: First, its almost entire noiselessness; second, its smooth and even surface; and third, its lack of necessity of repair except when it is almost entirely worn out.

BITUMINOUS PAVEMENTS.

Under this head should be considered sheet asphalt, asphalt block and bitulithic pavements.

Sheet asphalt pavements have been in general use for thirty years and have come into favor more rapidly than any other material. This pavement is smooth, pleasing to drive over, easily cleaned, and easily repaired. It is, also, comparatively cheap. It is especially adapted for residential and light retail-business streets.

Asphalt itself, while originally coming from the Island of Trinidad and Venezuela, has lately been produced in large quantities in California by the distillation of petroleum oil. This has materially reduced the cost of the pavement.

Upon the concrete foundation, is first laid a binder course, consisting of stone from 1 inch in diameter down to dust in size mixed with the asphaltic cement. If necessary, sand should be mixed with the broken stone and dust so as to fill the voids in the stone almost completely, but not to such an extent that the

wearing surface will not easily form a bond with it. The wearing surface is composed, roughly, of 10 per cent of bitumen and 90 per cent of sand and stone-dust, the bitumen being considered that part of the asphalt that is soluble in carbon disulphide. It is, too, the part of the asphalt that is of value in the pavement on account of its cementing properties.

The grading of the sand that is used in the pavement is important, as the function of the bitumen is simply to hold the particles of the sand and dust together; and the smaller the voids in the sand, the harder, more dense, and more stable will be the resulting mixture. As to the exact size, there is some question in the minds of different engineers, the maximum ranging from 1/10 to 1/4-inch in diameter; but whatever the maximum size, the grading should be gradual and complete, as before outlined.

The different ingredients are mixed at a central plant and taken upon the street and spread in such quantities that it will have, when rolled, a thickness of 1½ or 2 inches, according to the requirements of the specifications. The binder, previously referred to, should have a depth of 1 inch.

Great care should be taken in spreading the material on the street, so that it will be even and free from lumps and, when rolled, the entire surface will have a uniform density.

ASPHALT BLOCK.

Asphalt blocks are made at a central plant, and are 12 inches long, 5 inches wide, and 2 or 3 inches thick, according to the specifications. The mineral aggregate in the blocks is larger than that in the sheet asphalt and consists almost entirely of broken stone, the larger fragments being ¼-inch in diameter. On account of the character of the aggregate, the blocks are less slippery than ordinary sheet asphalt, and for that reason it is a desirable pavement on grades where a smooth pavement is desired. Being manufactured by machinery, the blocks are all subjected to exactly the same pressure, so that they are uniformly dense, and for that reason they wear evenly. As they are manufactured at one place, the wearing part of the pavement must be transported from the plant to the street. This

in many cases is a long distance, and consequently the pavement is somewhat more expensive than sheet asphalt. It has the advantage of being repaired without the use of any plant, as the blocks for repairs can be shipped at the same time as the construction blocks. For this reason this pavement is adaptable to small places where the amount of work would not be sufficient to justify the erection of a sheet asphalt plant.

Although especially desirable for the steeper grades, asphalt blocks are used to a great extent on streets where the gradient is light.

BITULITHIC.

This is a patented pavement, and consists of stone from 1 inch downwards so graduated that the voids shall not be less than 20 per cent. These voids are filled with either asphalt or some coal tar preparation. The idea of the patentee, originally, was to construct an improved macadam pavement, but, after certain experiments, it was ascertained that it would be possible to construct a durable and substantial pavement of this character. The pavement has come into very general use during the past ten years, and undoubtedly its use would have been more extensive had it not been a patented article.

The first pavement of this character was laid in Pawtucket, R. I., in 1901, where the grades range from 4.9 to 12 per cent. This pavement, even on these excessive grades, has given satisfaction.

REPAIRS.

It is extremely difficult to obtain accurate and valuable information concerning repairs to any kind of pavement. This is true for two reasons: First, because the different cities have not kept their accounts in such a way that it is possible to determine how much money has been expended on each or any street, even when the total amount is known; and, second, because few cities have money enough to keep their pavements in good condition, and too often the amount expended means simply that fact rather than the amount which was necessary to keep the pavements in repair.

The Borough of Brooklyn, New York City, however, during the last few years has kept its accounts in such a way that the cost of repairing any street in the borough can easily be determined. In 1913, the cost of repairs to the asphalt pavements, in this borough, out of guarantee was 3.5 cts., and in 1914, 2 cts. per sq. yd.; and in the Borough of Manhattan, for 1912, 14.1 cts.; for 1913, 13.8 cts., and for 1914, 9.5 cts. per sq. yard. It must be understood that the wear and tear on the pavements is very much less in Brooklyn than in Manhattan.

On something over three million square yards of asphalt pavements repaired in Buffalo, the costs were: 1911, 5.38 cts. per sq. yd.; 1912, 5.27 cts. per sq. yd.; 1913, 6.37 cts. per sq. yd.

In the City of Paris, in 1911, the cost of repairs to asphalt pavement was 19.5 cts. per sq. yard. In Berlin, asphalt repairs are made by contract; the price paid is, for streets from 5 to 20 years old, 10 cts. per sq. yd.; from 20 to 30 years old, 12½ cts. per sq. yd.; from 30 to 40 years old, 15 cents per sq. yd. The engineer in charge of pavements stated that often the contractor relaid the entire street surface, deeming it, where he had a contract for a long period, more economical than to do extended patching.

In London the contract price on Cheapside, per yard per year, was 16 cts. for fifteen years, beginning after the paving had been laid two years. The average cost of repairs in London on asphalt is 30 cts. per square yard.

In the Borough of Brooklyn, New York, the cost of repairs to Grade 1 granite-block pavement in 1913 was nothing, and in 1914, three mills per square yard. It must be remembered, however, that the streets with this pavement were all comparatively new.

In Buffalo the average cost per square yard for repairs to stone block pavements, on streets repaired only, was, for twelve years, $0.066 per year. On 17.762 sq. yds., that, in 1913, had been laid twenty-one years, the cost was 13.4 cts. per yard for that year.

In Paris, in 1911, the cost of repairs to stone pavement was 13 cts. per square yard.

Treated wood pavement has not been in use in this country long enough to obtain very positive information as to what it

should cost to keep it in good condition. From data gathered in 1912 from different cities in this country using wood, the following was ascertained:

In the Borough of Manhattan, New York, there were three streets that had been out of guarantee three years, one of heavy, one of medium, and one of light traffic. The heavy traffic street had cost 7 cts. per yard per year, while the average of all had been 6 cts. per yard per year; but the repairs were due practically all to settlements over trenches and damage by fire, except on the heavy traffic street.

The City of Minneapolis had, at that time, one million square yards of wood block pavement, the first of which was laid in 1902. The City Engineer stated, at that time, that the pavement had required practically no repairs, the cost in 1911 being less than 1/10 of a cent per square yard.

In St. Louis, in 1909, repairs to 50,000 square yards of wood pavement, laid in 1903, cost \$2.10, and in 1911, the same 50,000 yards cost less than 2/10 of a cent per yard. These pavements in St. Louis were all on light traffic streets.

In the Borough of Brooklyn, New York, the average cost per yard per year from 1909 to 1914, inclusive, on wood block streets out of guarantee, was 1.9 cts., and for the year 1914, 1.2 cts.

The cost of repairs to brick pavement is not so easily obtained, and in any event the cost would depend entirely upon the traffic. In Buffalo, however, the reports show that the cost of repairs to brick pavements on the streets repaired only was:

For the year ending June 30, 1907	\$0.0283	per sq. yd.
June 30, 1908	0.0384	" " "
June 30, 1909	0.0390	" " "
June 30, 1910	0.0151	" " "
June 30, 1911	0.0649	" " "
June 30, 1912	0.0609	" " "
June 30, 1913	0.0377	" " "

In should be said, too, in considering the question of repairs to any pavement, that the cost will vary according to the intelligence with which the material for the pavement has been selected and used. For instance, a granite pavement could be laid upon a street where it would require no repairs for fifty

years, while, on the other hand, an asphalt pavement might be laid on a street where it would be worn out entirely in three years. It must be assumed, however, in any discussion of such a subject that the materials have been selected judiciously and the pavement properly constructed.

SIDEWALKS.

Sidewalks are constructed of stone, cement, and brick, according to the availability of the different materials, and the cost varies in accordance with the distance the material has to be transported.

When sidewalks are not laid for the full width of the sidewalk space, as often occurs in residential districts. the question comes up as to whether they should be laid next to the curb or some distance back from it. If there is left a space of three or four feet between the outer edge of the walk and the curb, this can be sodded and used for planting trees. On the other hand, in the winter, when snow is on the ground, as the snow melts the water runs to the walk from both sides. If the walk in placed next to the curb, when cleaned of snow the water comes only from one side, and then flows freely to the gutter.

In cities where there is but a light snow fall, if sidewalks are only 5 feet wide, probably the best results will be obtained by laying the outside edges some three or four feet back from the curb.

In most American cities it has been the practice to allow property owners, in the business section of the city, to construct vaults under the sidewalk space out to the curb line, and sometimes even beyond. This is a practice which is not advisable. The street belongs to the public from property line to property line, and should be reserved to the public for its use. In modern times, when so many public utilities are placed underground, it would seem that the sidewalk space should be used for this purpose wherever possible. In foreign cities it is the practice to lay the sewer and the large water and gas mains in the roadway, but, wherever possible, to lay the others under the sidewalks. In this country, however, that practice has been followed to but a very slight extent, although at the present time the feeling in New York City is that it is advisable to do this.

The one thing which causes the most damage to American pavements is the constant disturbance by digging in the streets for the construction or repair of these underground utilities, and anything that will reduce this work will not only add to the life of the pavement, but materially reduce the cost of repairs. In many cases it will doubtless necessitate the construction of two lines for each utility in the street, but the connections to the property will be so much shorter and the cost of repairs so much less that undoubtedly it will be an economical proposition in the end. It may be somewhat difficult to bring this about in the business part of the cities where the utilities are already constructed under the roadways and vaults exist under the sidewalks, but in the outlying districts it is not only practicable but advisable to place these utilities in the sidewalk area.

STREET CLEANING.

The cost of cleaning streets, whether measured by the square yard of surface cleaned or the cubic yard of material removed, depends upon the character of the pavement, how well it is kept in repair, and how often it is cleaned; also, whether the work has been done by machinery or by hand.

In 1907, a commission was appointed by the Mayor of the City of New York to investigate this matter, and the following is quoted from the report of that commission:

"There is a very marked difference between the quantity of dust left upon the pavements of various kinds. Thus, if we call the average volume and weight collected from the sheet asphalt pavement 100, the relative quantities from other kinds of pavements were:

	Volume	Weight
From sheet asphalt	100	100
From block asphalt	130	182
From wood block *	332	145
From granite block	1,081	912

* It should be said that the wood block pavement on which the examination was made is one of the oldest of its kind in the city, and its surface, being uneven, caught and held an unusual quantity of dust. Wood block pavement, when comparatively new, should compare favorably with asphalt-block pavement in its freedom from dust-retaining qualities.

"After careful consideration of all the facts available, we estimate the average relative cost of cleaning, equally well, the various kinds of pavement in use in the City under similar conditions of repair, as follows:

Sheet asphalt pavement	100
Wood block pavement (new)	105
Asphalt block pavement	115
Brick pavement	120
Wood block pavement (old)	125
Medina block pavement	130
Granite block pavement	140
Belgian block pavement	150
Cobblestone pavement	2,000

"On the assumption of 100 cleanings per year it may be shown that the annual cost of cleaning equally well a mile of each of the pavements named, over what it would be if sheet asphalt were substituted, would be as follows:

Wood block pavement (new)	$ 26.40
Asphalt block pavement (average condition)	79.20
Brick pavement	105.60
Wood block pavement (old)	132,60
Medina block pavement	158.40
Granite block pavement	211.20
Belgian block pavement	264.00
Cobblestone pavement	1,584.00"

While this is the result of a study, it was the work of experienced men, with all the data that were available, so that the results are undoubtedly approximately correct.

DISCUSSION

Mr. M. M. O'Shaughnessy,† M. Am. Soc. C. E., said that in San Francisco, grades exceeding 3 percent are not desirable for wagon traffic, and over 10 percent are undesirable for trolley, while there is no limit for cable cars. For asphalt pavement for San Francisco 8 percent is the maximum allowable. For grades of more than 8 percent where asphalt pavement is desired, the center of the street is paved with basalt block for the heavier traffic. The question of foundations is largely local. In California foundations present less difficulty than in the East on account of the absence of frozen ground. Mr. O'Shaughnessy.

† City Engr., San Francisco, Calif.

Mr. O'Shaughnessy. In his opinion, the most vital problems in connection with streets are sub-sidewalk space, conduits and increased width. Laxity of our laws permits parallel pipes for public utilities and allows too much chopping of the street surface. Re-patched surfaces are not as good as original surfaces. Laws should be enacted to prevent this "parallel work". He believed that if property owners use sidewalk space, they should pay rental to the city.

Mr. Dimock. **Mr. A. H. Dimock,**† M. Am. Soc. C. E., referring to conditions in Seattle, said that Second Avenue in that city recently had been narrowed from 58 feet to 54 feet and the sidewalks widened from 16 feet to 18 feet. Eighteen feet are allowed for the street cars and nine feet for each additional line of traffic. The street is known as a "six-line" traffic street. For a wider street, add eighteen feet for two additional lines of traffic. In practice, 48 feet is too narrow for three lines of traffic. He said that a maximum grade of 3 percent had been laid out in Seattle for horse and wagon traffic, although 5 percent is not too large for a maximum. The expense for reducing the grade is too great at times. In Seattle the construction of brick streets is a local industry. Re-pressed brick had been abandoned on account of the interior laminations in the brick, resulting from the pressing process, and wire-cut brick had been adopted. For a filler, Portland cement grout is good, but adds considerable noise, and it is necessary to keep the traffic off the street until the grout has set. On one street, sand and planks were kept over the cement grout for two months. To overcome this delay in traffic, a good bituminous filler is advised. Noise is not as important a factor as formerly, on account of the rubber tires on vehicles. Street cars apparently cause most of the noise. He expressed approval of the suggestion of payment of rent by property owners who use sidewalk or sub-sidewalk space.

Mr. Pope. **Mr. C. S. Pope,*** M. Am. Soc. C. E., referring to conditions in Los Angeles, said that on very steep grades, as 15 percent or 20 percent, the street must necessarily be wider to allow machines to turn around half way up the hill, as some machines find difficulty in getting to the top; so the steeper the grade, the wider the street. The kind of pavement also affects the possible grade, and, of course, the converse is true.

Mr. Durham. **Mr. H. W. Durham,**** M. Am. Soc. C. E. (by letter), expressed a feeling of regret that the limits imposed upon the author by the Congress did not permit a more adequate treatment of this subject, and said that in reading the paper one must bear these limitations in mind. Also he felt that it is difficult either to treat all subheads with proper perspective, or to avoid generalizations, when one is confined to narrow limits of space; generalization does not in all cases agree with more detailed studies.

He thought that certain points touched on by the author might be selected for comment. Mr. Tillson's definition of the province of streets

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** Consult. Engr., New York, N. Y.

must be broadened to include, in all great cities, the providing of a subsurface location for the circulation of all varieties of all public utilities, such as electricity in its various developments, telephone, telegraph, electric light and power, water, gas, sewers, steam pipes, pneumatic tubes, etc. Subways, of course, in their various forms, and elevated railways may be included as among the means provided for intraurban traffic. Mr. Durham.

The question of width of streets is one that is bound up in the question of location, and both fall within the province of the city planner rather than that of the street maintainer; except that the latter, in his capacity of conserver of the existing street system of a great city, is frequently confronted with the problem of providing for the enlargement of ways that were originally designed without regard to future development.

The problems of the relation of width of street to height of buildings, and to traffic, are not independent of each other. Not only will an increased traffic demand higher buildings, but, on the other hand, the widening of the streets and the increase of the height of buildings will increase the traffic.

In view of the constantly changing character of our streets in American cities, it is very doubtful if it would be desirable to apportion sidewalk and roadway widths strictly to meet local conditions. In such a city as New York, the most modern development in the wholesale district is to provide for the loading of goods within the buildings, thus obviating the obstruction of roadway by vehicles, and there are few streets in this city, even within the wholesale district, where the rights of the pedestrian are not an important matter. It will probably be desirable, in some of the very narrow and congested streets downtown in New York, to increase roadway accommodation by the expedient adopted in some European cities, where the footways are in an arcade within the building line, and the entire street width can be given up to vehicular traffic.

Mr. Durham agrees with the author that the selection of the type of street surface to be employed is a considerable problem, although it seems to him not a matter of extreme difficulty of solution at the present time. Until within the past century, it has not been the subject of much discussion. From the time of the ancients onward, the only method of surfacing streets within cities has been by the use of stone blocks of various shapes and sizes, usually cobbles, but sometimes employing rubble construction, as was done by the Romans. The studies of Tresauguet and his successors brought about the greatest change that remained standard until the rapid introduction of motor-propelled vehicles with rubber tires, and heavy loads revolutionized again our road problem.

During, and previous to, this period, however, and covering approximately the time of the nineteenth century, the leading cities of Europe developed first the pavements of dressed-stone blocks, then the smooth surface of rock asphalt, and later the modern creosoted-wood pavements. If we eliminate from our present discussion the various other possibilities

Mr. Durham.

of good surfaces which have been developed for suburban roads, and add only the extensive use of brick which has been developed in the Middle West, and employed with satisfaction in our smaller cities, we find that street surfaces for our large American cities must be selected from classes similar to those developed abroad.

Referring to the author's comment regarding the question of hardness and toughness of stone paving blocks, Mr. Durham thought it of interest to note that tests of granite, made by himself, from all quarries supplying rock available for New York City paving blocks, and including samples from Germany, Sweden and Wales, carried out in accordance with the standards of the U. S. Office of Public Roads and the American Society for Testing Materials, showed that for abrasion and hardness the variation is slight, and all come within the class termed ''hard''. The tests also showed that the variations for toughness among the same samples were, with a few exceptions, also small, and indicated that almost all granites possess a low toughness or ability to resist fracture under impact. We should, therefore, have to eliminate granite altogether from among the available stones for paving blocks acceptable under a strict adherence to theoretical qualities, and would probably be limited to trap for our ideal. As a matter of fact, the latter, while acceptable for modern traffic, does not by any means meet the requirements which granite satisfies.

The fact which has been developed by recent stone-block pavement construction in our country, and which has been known in Great Britain, France and Germany for many years, is that the important feature requisite to secure a good stone-block pavement is accurate dressing and close fitting of the blocks, so that the heads are plane and the joints a minimum. When this is the case, the blocks cannot wear round at the edges, and the effect of traffic under these conditions on a good granite from any quarry, whether it be of the type popularly known as ''soft'' or ''hard'', will be very similar, as can be observed on many of the downtown streets of New York City paved within recent years under modern specifications.

With regard to wood pavements, he states that they are most successfully constructed in Great Britain, particularly in London, where, by the use of Norway pine, somewhat softer than the yellow pine most common in our country, there has resulted a wearing surface unequalled anywhere else for smoothness and quiet, combined with a comparative absence of slipperiness. Under ordinary heavy traffic, however, these pavements are good for only ten years instead of forty, which the author has estimated as the probable life of the best American wood surface. It should be noted, however, that the latter has never been attained in practice, as our wood surfaces, like others, are generally destroyed by the process of making repeated openings for subsurface installations.

Wood pavements have not proved as successful or popular in the Continental cities as in Great Britain, and Paris has at present extensive contracts for the substitution of asphalt surface for the old wood. In the cities of Germany, wood is used only for short sections where the grade is greater than is desirable for asphalt. The Australian hardwood blocks, while appa-

rently successful in their own cities, have, in general, proved a failure in comparison with soft wood in Great Britain. On some light-traffic streets in Holland and Germany, where the construction is comparatively new, they appear to have been successful. Mr. Durham.

The author's statement as to the origin of asphalt should be amplified by the inclusion of Mexico as a source for much of this material.

There should be noted the possibility of constructing asphalt pavements in place with the same type of aggregate as is used in the construction of asphalt block, if it is desired to eliminate the condition of slipperiness on hills.

At the present time plants for the production of hot asphalt mixtures are so frequently distributed throughout the country, and can be procured at such comparatively low cost for a small output, that there is not usually justification for the paying of extra prices for a pavement composed of asphalt block, over the cost of one of a sheet mixture. This type of street surface, in comparison with sheet asphalt, is relatively used only to a small extent in our cities. The repair advantage becomes slight when it is considered that the blocks are merely small sections of an asphalt-concrete pavement, with the same inherent tendency to alteration of shape under extreme temperature and pressure; and, consequently, it is seldom found after considerable wear that the new blocks can be accurately fitted into the place of old ones.

In reference to the discussion of repairs to pavements in Manhattan, Mr. Durham called attention to the fact that such repairs during 1912-1913 were executed by contractors at a unit price per square yard for the work done, while during a large portion of the year 1914 the work was done by the Municipal Asphalt Plant which was put into operation during the spring of that year, under his direction. Before this plant had been in use for many months, it was possible to cancel all outstanding contracts for street repairs, and to carry on all the required maintenance on about three million square yards of asphalt pavement by city forces.

Reference to the annual report of the Department of Works of the city of Paris, for the year 1912, gives some slight amplification of the author's figures. The area of asphalt roadways maintained by the department at the close of the year 1911 was 548,880 sq. yds., and at the close of the following year (1912), 573,720 sq. yds., a comparatively small area when contrasted with the figures for the Borough of Manhattan, or other American cities.

Its maintenance cost per square yard was, during 1911, 22 cts., and during 1912, 17.4 cts. per sq. yd. On the other hand, Paris, at the close of the year 1912, had about 2,862,036 sq. yds. of wood pavement, whose maintenance cost was, during 1911, 32 cts., and during 1912, 28.5 cts. per sq. yd.; and as illustrating what class of pavement was employed to the greatest extent, there must be noted that at the close of 1912 there was on the streets of Paris 6,546,144 sq. yds. of stone-block surface, which was annually maintained at a cost of about 14.7 cts. per sq. yd., as against 15.5 cts. in 1911. In Berlin, asphalt contracts include free maintenance for the

Mr. Durham. first four years, followed by a maintenance period of fifteen years at 10 cts. per sq. yd. a year. At the expiration of the nineteen-year period, a new contract is made for a ten-year period at 12 cts. per sq. yd., with another increase to 14 cts. per sq. yd. from the thirtieth to the fortieth year, with a possibility of additional extension after this time, should the municipality so desire.

As regards London, it is impossible to give with any accuracy an average cost for the maintenance of any class of pavement, inasmuch as streets are maintained under the direction of twenty-nine separate borough organizations, in accordance with as many different methods. In some, the work is done by day labor; in others, it is entirely done by contract. Victoria Street between Parliament Square and the Victoria Station, which has an excellent asphalt surface, is at present being maintained by annual contract at a cost of nearly 60 cts. per sq. yd. In the city of London, which in an area of one square mile has about fifty miles of street, the average annual cost for maintenance during 1913 was, for wood pavement, 24 cts. per sq. yd.; asphalt pavement, 42 cts. per sq. yd.; the work being done under a fifteen-year contract.

Such figures can be quoted indefinitely, and merely tend to show the impossibility of making any comparison between different cities, without exhaustive research into the various conditions governing the methods employed for maintenance. Almost all discussions on this subject take for granted a common factor which seldom exists, namely, that the streets are all maintained in a constant state of efficiency. This factor must be added to the author's assumption as to the judicious selection of materials and proper construction of the pavement, before we can have any basis for comparisons.

Under the head of sidewalk or footways, the author touches a subject which at present is handled only theoretically in our country. Throughout the cities of Europe, the entire street surface, from building to building, is assumed to be available for public use, and, as stated, the area under sidewalks is largely used, and is most suitable, for many classes of public service lines, such as telephone, telegraph, gas and water service for adjacent buildings, etc. Until our American cities adopt a definite policy for utilizing the entire space within the street width, and abandon the present practice of allowing each building owner to do as he sees fit with the space below the sidewalk, we will continue to have the confusion which is at present visible on the streets of New York, where they are being opened for subway construction. A large part of the frequent tearing up of new pavement surface is due to our disorderly practice in this regard. The important Continental cities, and particularly those of Germany, have official plans showing locations which all subsurface constructions shall take in each street, and all new installations are required to conform to these regulations. Another point in which they greatly surpass us is in careful attention to the details of design. Recently there has been some discussion as to the advantages of longer radius curves for curbs at intersections. This, while an innovation for many of our American cities, is standard practice abroad.

Mr. Durham.

The Western cities of the United States are ahead of many of those in the East in this regard. By giving the curb at corners a radius equal to the width of the narrower of the two intersecting sidewalks, ample provision is made for foot traffic, and the turning of vehicles from one street into another is expedited. Such minor matters as placing of storm-water inlets at more frequent intervals and away from corners, so as to avoid large streams of running water at points where pedestrians cross in wet weather, have heretofore received little attention in American cities, while carefully considered, as a matter of course, abroad. These few points are merely mentioned to emphasize the necessity of our giving more attention to details.

In conclusion, Mr. Durham felt the lesson to be derived from any discussions of this important subject should be to emphasize the primary importance of the adoption in each locality of a proper city plan, adequate not only for present, but for probable future needs, and including a system for future development with provisions for locating subsurface structures as they are needed; and finally, and most important, should be the recognition of the fact that all good plans and specifications are valueless without constant attention to the proper carrying out of all details of construction, and to the maintenance of the work after its completion. With proper inspection, good work can be attained, even though poor specifications be followed; without it, the best specifications are valueless; while no amount of careful original construction will produce satisfactory work, unless it receive, subsequently, careful and continuous inspection and immediate attention to the repairing of defects as they develop.

Mr. Jubb.

Mr. S. A. Jubb,†† M. Am. Soc. C. E., referred to the difficulty of sub-service for public utility lines, especially as in Boston, where the problem is complicated by underground transit. The water mains must also be below freezing level. Separate sewers, water mains, gas and electric-light conduits, etc., are placed on each side of the subway. When the subway was installed in Boston, vault areas under the sidewalk were arbitrarily taken over by the city, the property owners being ordered to relinquish their claims. Engineers in charge of street constructions such as this, should insist on the installation of separate public utilities service on each side of the underground transit system.

Mr. Holcomb.

Mr. Chas. H. Holcomb* referred to an important omission in the discussion thus far, namely: the fact that present designs for streets, both in plan and in grade, are the result of conditions now existing due to faulty planning at earlier times. In the opening of new suburban tracts, too much authority is allowed the individual. He instanced the Potrero Hills in San Francisco. The streets on these hills should have been laid out in contours and not running up and down the hill. The city authorities should be empowered to control by the establishment of standard designs, such private improvements as just mentioned, and the grades should be established on a street after the improvements are made.

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* City Engr.'s Office, San Francisco, Calif.

Mr. MacGregor.

Mr. R. A. MacGregor,‡ M. Am. Soc. C. E., referring to the life of pavements, said that in Manhattan Borough, N. Y., asphalt of six years' standing has had repaired 30 percent of its total area, while one asphalt pavement of thirty years' standing has had 14 percent of its total area repaired during the past year. However, there are granite pavements that have been down 25 to 30 years with but little repair. All New York City contracts on pavements call for a five-year guaranty against repairs.

Mr. Grunsky.

Mr. C. E. Grunsky,* M. Am. Soc. C. E., thought that with profit to the profession Mr. Tillson might well have devoted more attention to the required width of streets. The streets of our great American cities, with the exception of Washington, were laid out to accommodate the business originating in buildings 3 to 6 stories in height, before elevators were in use and before the advent of the ''sky scraper''. The streets, as they now exist, are too narrow for the traffic. Owing to the expense involved, widening in the business sections of the large cities is almost always out of the question. Were it not for the fact that the automobile and the auto-truck have increased the traffic capacity of the streets four-fold or more, the congestion in the down-town sections of New York and other cities that could be named would be unbearable.

The writer, some twelve years ago, while City Engineer of San Francisco, expressed the belief that the time would come when, for sanitary reasons, the horse, except for pleasure use, would be prohibited on the streets of some of our American cities. He suggested that this fact might well be taken into account in prescribing the type of pavements and was always as emphatic as circumstances would justify in advocating a smooth pavement. The horse at one time deserved, and under certain circumstances still deserves, special consideration. It had to be given a pavement on which it could secure a good foothold. The truck, too, had to be considered. This was especially true in San Francisco, where dead-axe, springless trucks—''pavement smashers''—had become popular. For these trucks, basalt or granite block pavements had to be provided, which were an abomination to every one doing business upon the street or occupying offices within half a block thereof. Now, this is different. The relative number of auto-trucks is increasing rapidly. The character of traffic may be trusted to adjust itself to the pavement. A thin sheet asphalt will now serve for heavy traffic where it could not be used a few years ago. Brick pavements, too, can be more generally used than formerly and will, in time, replace many of the stretches of basalt or granite blocks and of cobbles on the streets with grades of 10 to 20 percent or more.

In nearly every large city where residences are crowded there will be found in the rear an air space, generally of fair dimensions, devoted to flower gardens. The back garden or cluster of back gardens is frequently a beauty spot. How much more these gardens would add to the attractiveness of the city if they could only be transferred, in part at

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* Cons. Engr., San Francisco, Calif.

Mr. Grunsky.

least, from the rear to the front of the house! And they might have been, if only the original landowner had had the foresight to realize that he would have lost nothing by making the street in front of the property 120 feet wide instead of 60 feet.

There is no reason why a street 120 feet in width should be improved to a width of more than 60 feet until the traffic requirements make increased width necessary. The other 60 feet can be left between sidewalk and building line for garden use by the property owners, thereby giving the resident all the advantage of ownership and yet holding this area available to be made a part of the area used by the traffic whenever this becomes necessary.

By this arrangement the public will for all time be in control of an area which at some time in the future may be required for traffic, for street railways, subways or other uses. The street moreover will always be more attractive with the buildings set well back, than if the property owners were allowed, as at present, to push them out against the sidewalk.

Mr. O'Shaughnessy.

Mr. M. M. O'Shaughnessy,* M. Am. Soc. C. E. (by letter), referring to the width of streets said that the rule suggested by Mr. Tillson that the height of a building should be limited to the width of the street on which it stands is impracticable in the business districts of any large American city. Neither is it a desirable restriction, except in exclusively residential sections. In fact, had such a rule ever been applied throughout any city, it is safe to say that the commercial development of that city would have been thereby greatly retarded while such legislation was in force. A building law restricting heights to one and one-half times the width of the fronting street in business sections of a city would seem reasonable.

Referring to pavement foundations, Mr. Tillson states that, "the common practice is to mix the concrete in the proportions of one part of cement to three parts of sand and six parts of broken stone of a size ranging from two inches downward". While this is the common practice in many cities, he desired to note that to such haphazard proportioning of ingredients can be attributed the failure of many concrete pavement foundations. It has been the experience in San Francisco that a study of the materials composing pavement foundation aggregates has perceptibly raised the standard of street construction. Such a study, moreover, tends greatly toward economy, for by proper proportionment of the ingredients in the aggregate, the quantity of cement, the most expensive component, can often be reduced without impairing the density, strength or impermeability of the concrete. Mechanical analysis, the volumetric synthesis as described in Taylor and Thompson's "Concrete, Plain and Reinforced", pages 187 and 209, has, for several years, been practiced in our city testing laboratory, with decidedly successful results. Instead of providing for a 1:3:6, a 1:2:4, or a similar definite mixture, the specifications now issued by the City Engineer's

* City Engr., San Francisco, Calif.

Mr. O'Shaughnessy.

Department of San Francisco require that, "The concrete shall be composed of mortar and broken rock or gravel; the mortar shall consist of Portland cement and sand in the proportion of one (1) cubic foot of cement to two and one-half (2½) cubic feet of sand, and sufficient mortar shall be used in the concrete to completely fill the voids in the broken rock or gravel". This leaves the proportion of rock undetermined until the materials are on the work, when samples are brought by the inspector to the engineering testing laboratory and the correct proportions then determined.

In this connection, the importance of the modern testing laboratory in securing good streets can not be too strongly emphasized. Not only are tests of concrete for pavement base essential, but of even greater importance is an accurate laboratory determination of the consistency of asphalt wearing surface. On every unit of asphalt pavement that is laid in this city, daily tests are made both of the asphalt cement and on samples of the wearing surface as laid. A complete office record is kept of these tests, so that it is possible, from day to day, to regulate the mix and keep the aggregate up to the required standard. The grade and quantity of the cement, the composition and consistency of the asphalt, its penetration according to the D. C. Standard, and, finally, the mesh composition of the sand in the surface mixture, are all determined. The following specifications must be fulfilled:

"The asphalt cement must be a California product. It may be either an oil residuum asphalt or a natural solid asphalt. All shipments of the asphalt cement shall be marked with the lot number and the penetration, and no shipment will be accepted where the penetration does not lie between the limits of 60 and 120 penetration by D. C. Standard. Ten samples taken at random shall not vary more than 15 percent from the average lot penetration.

"In preparing the asphalt cement for use in the wearing surface mixture, such portions of the harder and the soft materials shall be melted together in the kettle as will give a product having a penetration within the limits of 70 and 90 D. C. Standard. During the entire period of heating, the mixture shall be thoroughly agitated by air or by mechanical means, and the resulting asphalt cement must be of a uniform and homogeneous consistency. Live steam shall not be injected into the mixture. The heat must be so applied that there can be no burning of any portion of the asphalt cement and the temperature shall be maintained between 280 degrees Fahrenheit and 300 degrees Fahrenheit.

"When 20 grams of the asphalt cement are heated for five consecutive hours at a temperature of 326 degrees Fahrenheit in a tin dish, 2½ inches in diameter under uniform conditions, there must not be volatilized more than five percent of the bitumen, nor shall the penetration at 77 degrees Fahrenheit after such heating be less than 20 D. C. Standard.

"At least 98½ percent of the asphalt cement shall be soluble in

cold carbon tetrachloride and at least 99½ percent shall be soluble in cold carbon bisulphide. Mr. O'Shaughnessy.

"Stone dust shall be Portland cement or ground limestone, or it may be any crystalline or sharp fragmental material free from loam or organic matter and must have a specific gravity of not less than 2.5. It must be so pulverized that all will pass a No. 50 screen and at least 75 percent will pass a No. 200 screen. Sand must be clean, hard and sharp. It must all pass a 10 mesh to the inch screen and must not contain more than 3 percent of mica, clay or other inferior ingredients.

"Asphaltic wearing surface. Upon the binder course shall be laid an asphaltic wearing surface composed of asphalt cement, sand and stone dust. The materials must be mixed in such proportions that the percentage composition (by weight) of the wearing surface shall be within the following specified limits:

(1) Bitumen soluble in cold carbon bisulphide, between 10 percent and 12 percent.

(2) Sand, stone-dust, and other inorganic ingredients.

Passing Screen Mesh No.	Rejected by Screen of Mesh No.	
200	------	between 12 per cent and 15 per cent.
80	200	between 20 per cent and 34 per cent.
50	80	between 20 per cent and 34 per cent.
30	50	between 11 per cent and 20 per cent.
20	30	between 4 per cent and 10 per cent.
10	20	between 1½ per cent and 5 per cent.

At least 10 percent, and not more than 18 percent of the wearing surface mixture shall be stone-dust".

The wearing surface mixture may be prepared by mixing the bitumen in the form of asphalt cement with the sand and stone dust or by the combination of natural bituminous materials with the necessary ingredients to produce the proper mixture.

By scientific grading of asphalt paving materials the life of asphalt pavements in San Francisco has been increased several hundred percent. Their excellence can best be appreciated after an extensive examination, which interested members of the Engineering Congress are cordially invited to make.

Mr. Geo. W. Tillson, in closing, had very little to say in regard to the discussions. He does, however, quite agree with Mr. O'Shaughnessy that a restriction providing that the height of buildings should not be more than one and one-half times the width of the street in business sections of the city would be satisfactory, and it was a slip on the author's part that the paper was not so written. Mr. Tillson.

Paper No. 60

RURAL HIGHWAYS.

By

L. W. PAGE

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Washington, D. C., U. S. A.

INTRODUCTION.

The subject of this paper, "Rural Highways," presents so many features which are worthy of discussion before a congress of engineers such as this that it is absolutely impossible even to touch on all of them in a single address of reasonable length. A less inclusive title, however, would hardly cover the points which would appear to be of most interest to the engineering profession and which it is purposed to discuss at this time. These points relate to economic efficiency in planning public road improvement, scientific methods of construction, and intelligent maintenance.

Since public road improvement is already a fixed and continuous policy of all civilized nations and since public sentiment in favor of improved roads is practically universal, no further introduction of the subject seems necessary.

ECONOMIC CONSIDERATIONS.

The fundamental problems which confront an engineer in dealing with public road improvement are concerned with determining, first, which roads should be improved; second, what types of improvement should be employed; and, third, what methods of construction and maintenance are most efficient. To solve these problems intelligently requires skill in handling questions of economics in addition to engineering ability. In other words, the highway engineer should be able to determine what to build and where to build it, as well as how the building is to be done, and he should bear in mind that as much waste is likely to result from improving the wrong roads or employ-

ing wrong types of improvement as from using faulty materials or methods in making the improvements. It seems well to consider briefly, therefore, the extent to which determinations of each character may be rationalized.

The only reasonable basis for determining which of perhaps a great number of public roads in a community should be improved, or the order in which improvements should take place, is public convenience. In order to make each improvement add the maximum amount to the convenience of the public, however, it is necessary that the engineer who plans the improvements must have a comprehensive understanding of the economic and social relationship which exists between different parts of the community under consideration and also the effect which different roads, if improved, would have in making this relationship more advantageous.

In order to gain a comprehensive understanding of this kind it is usually necessary for the engineer to prepare a plan showing the various highways in proper relation to each other, and showing also how population and industries are distributed. The amount and character of traffic using each important road, or which would use an improved road having the same location, may be estimated by means of traffic counts or otherwise, and should be shown on the plan.

With such a plan before him, it is practicable for an engineer to lay out an intelligent system of improved highways which would accommodate the entire community, and to assign relative weights to each unit of the system according to its importance. This system would serve as a model toward the development of which all road improvement work should be directed, but which might be readily modified to meet the exigencies arising as the system developed.

A typical plan for a model system such as that described above is shown in Plate I. This plan is deficient in that it embraces only one county, and therefore fails to show the intercounty relationship which might have a very strong bearing on the relative importance of the different highways. Reference will be made to this plan again in the following paragraphs, which discuss the matter of determining the most advantageous types of improvement to employ.

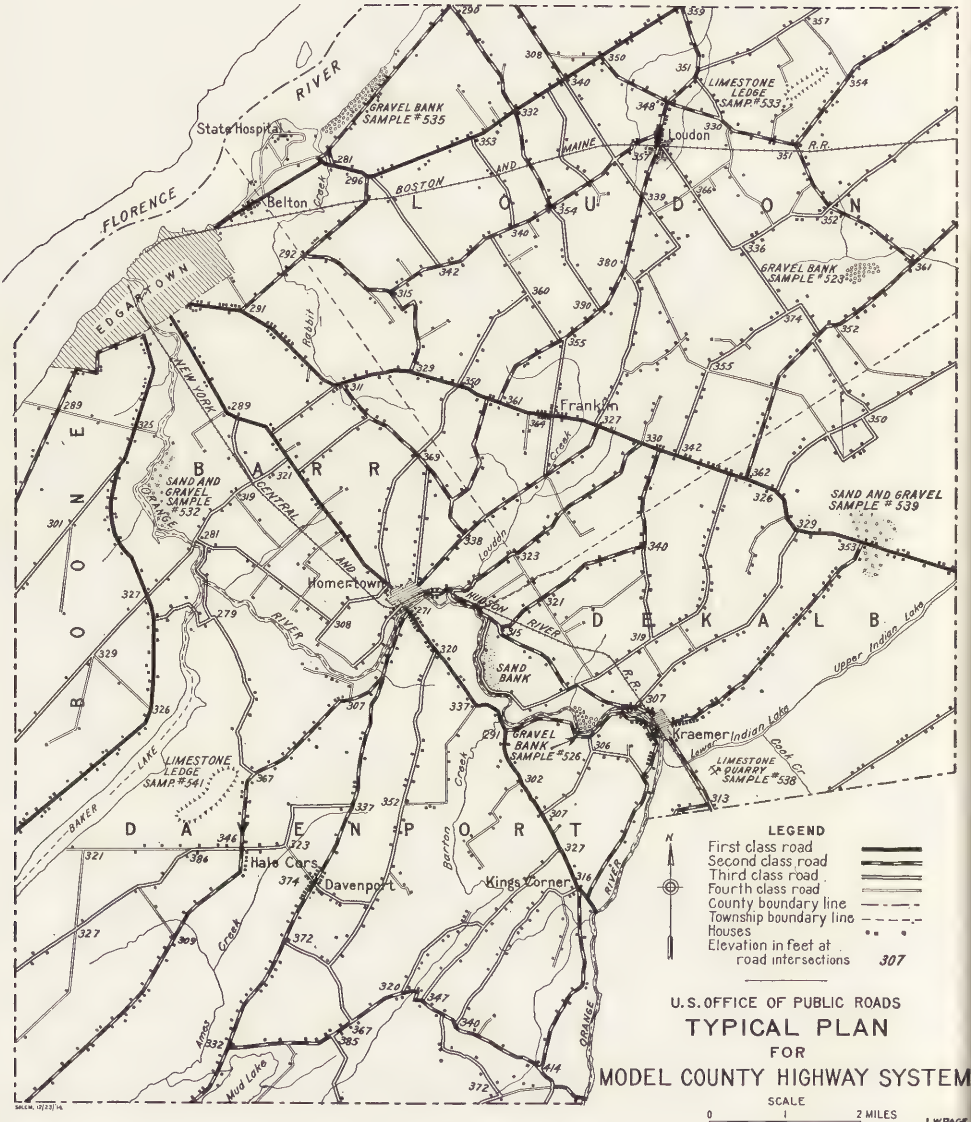
FLORENCE RIVER
State Hospital
Belton
EDGARTOWN
GRAVEL BANK SAMPLE #535
BOSTON AND MAINE R.R.
Loudon
LIMESTONE LEDGE SAMP. #533
L O U D O N
GRAVEL BANK SAMPLE #523
Rabbit Creek
Franklin
B A R R
SAND AND GRAVEL SAMPLE #532
NEW YORK CENTRAL AND HUDSON RIVER R.R.
ORANGE RIVER
Hometown
SAND AND GRAVEL SAMPLE #539
D E K A L B
B O O N E
SAND BANK
GRAVEL BANK SAMPLE #526
Kraemer
Lower Indian Lake
Upper Indian Lake
LIMESTONE QUARRY SAMPLE #538
Cook Cr.
LIMESTONE LEDGE SAMP. #541
BAKER LAKE
D A V E N P O R T
Hale Cors.
Davenport
Barton Creek
Kings Corner
Amos Creek
Mud Lake
LEGEND
First class road
Second class road
Third class road
Fourth class road
County boundary line
Township boundary line
Houses
Elevation in feet at road intersections 307
U.S. OFFICE OF PUBLIC ROADS
TYPICAL PLAN
FOR
MODEL COUNTY HIGHWAY SYSTEM
SCALE
0 1 2 MILES
L.W.PAGE

Plate I.

The proper type of improvement for any particular road ordinarily depends for the most part on purely economic considerations. That is, the type selected should ordinarily be shown to have a net economic advantage over any other type which might be selected. The economic efficiency of improved roads is affected by a number of factors, some of which are usually more or less indeterminate, but an intelligent evaluation of these factors evidently forms a much more satisfactory basis for making comparisons than would be formed by any set of arbitrary assumptions. Attempting to compare types of improved roads without first evaluating the factors which affect their economic efficiency is in fact very much like attempting to estimate volumes of solids without first estimating their linear dimensions, and is almost as indefensible.

The principal factors which affect the economic efficiency of an improved road and upon which economic comparisons should be based are: First, cost of construction; second, cost of maintenance; third, amount and character of traffic; and fourth, the average unit cost of hauling before and after the improvement is made. If these factors are all intelligently considered for each of the types of any ordinary road, it is apparent that the most economical type in theory may be readily selected.

The first factor, cost of construction, can usually be satisfactorily estimated for any particular road, when the conditions which affect the availability of materials, the character of labor, the prevailing gradients, etc., are understood. These conditions should all be indicated on the model system plan as is done on Plate I, where such a plan is employed, and should be sufficiently complete to obviate all probability of large errors in preparing the estimates.

The second factor, cost of maintenance, is dependent on the character of material used, the volume and character of traffic, and the climatic and topographic conditions which affect the road under consideration. This array of variables, especially when it is considered that traffic conditions are constantly changing, makes the cost of maintenance appear at first glance almost indeterminate. For most types of road improvement, however, the effect of these variables can be estimated within

reasonably close limits from the data already available, and the Office of Public Roads and Rural Engineering, is now working in cooperation with State highway departments and other interested persons in an effort to make these data more nearly complete. It is hoped that within a short time the information which is being collected can be so reduced and correlated that the cost of maintaining any particular type of improved road, under any given set of ordinary conditions, can be estimated with a very satisfactory degree of accuracy.

The third factor, amount and character of traffic, has its principal importance, from an economic view point, in the effect which it has on the cost of maintenance. Every road should of course be designed to further the convenience of traffic and the comfort of travelers, but almost any type of improved road, when properly constructed and maintained, will meet this requirement. Traffic data are usually collected by means of counts, but the estimates upon which economic comparisons are based must frequently be modified from what the counts would indicate in order to allow for the changes which are likely to result from the improvement itself and from other probable economic changes in the community.

The fourth factor, average unit cost of hauling before and after the improvement, varies very slightly for different types of improved roads, provided that they are all equally well maintained. The real economic justification for improving any road hinges on this matter of reduction in the cost of hauling, however, and it, therefore, deserves the most careful consideration. If the unit cost of hauling before and after the improvement, and the total volume of traffic using the road are known, the total annual saving resulting from the improvement can evidently be estimated; and, if the improvement is to be justified economically, this total annual saving must be sufficient, after all costs for maintenance and repairs are deducted, to pay a reasonable interest on the original investment. To determine what type of improvement will return the largest net rate of interest on the original investment is the sole purpose of making an economic investigation.

Road improvements may of course sometimes be justified by other than purely economic considerations, as, for example,

when a wealthy community constructs a highly improved road simply to increase the pleasure of travel, they need no further justification than that they are willing to pay for it. Such improvements, however, are to be classed as luxuries and the community adopting them should so understand. A more frequent example of poor economy, but perhaps good politics, is the "Through Highway" connecting large centers of population. While such highways undoubtedly serve an economic function, one of their principal purposes in most cases is to accommodate pleasure traffic originating and ending in the cities. This class of traffic of course deserves consideration and must be accommodated in some way, but in making economic investigations, the engineer should be very careful to show to what extent the matter of caring for pleasure traffic is allowed to influence his plans, and should also show, as far as possible, just how this influence will affect the cost of the improvement.

If a model system of highways, such as that shown in Plate I, has been previously worked out, and the importance of each unit in the system has been properly weighed, it is apparent that the investigation for determining the proper type of improvement to employ on each road will be greatly simplified. It is also apparent that the more comprehensive this system can be made within reasonable limits, the less will be the duplication of work required and the greater will be the possibility of securing satisfactory results through efficient organization. The state is therefore much better circumstanced for planning and supervising road improvement work than are any of its political subdivisions. This is evidently true, even though the officials controlling road work in the subdivisions are as honest and intelligent as those composing the state organization.

The chart shown in Plate II is intended to illustrate the scope of a model state organization and is based on several existing ones which are at present accomplishing very satisfactory results. It is evident that with an organization of this kind, the experience gained and data collected in each section of a state can be turned to the greatest possible advantage in every other section.

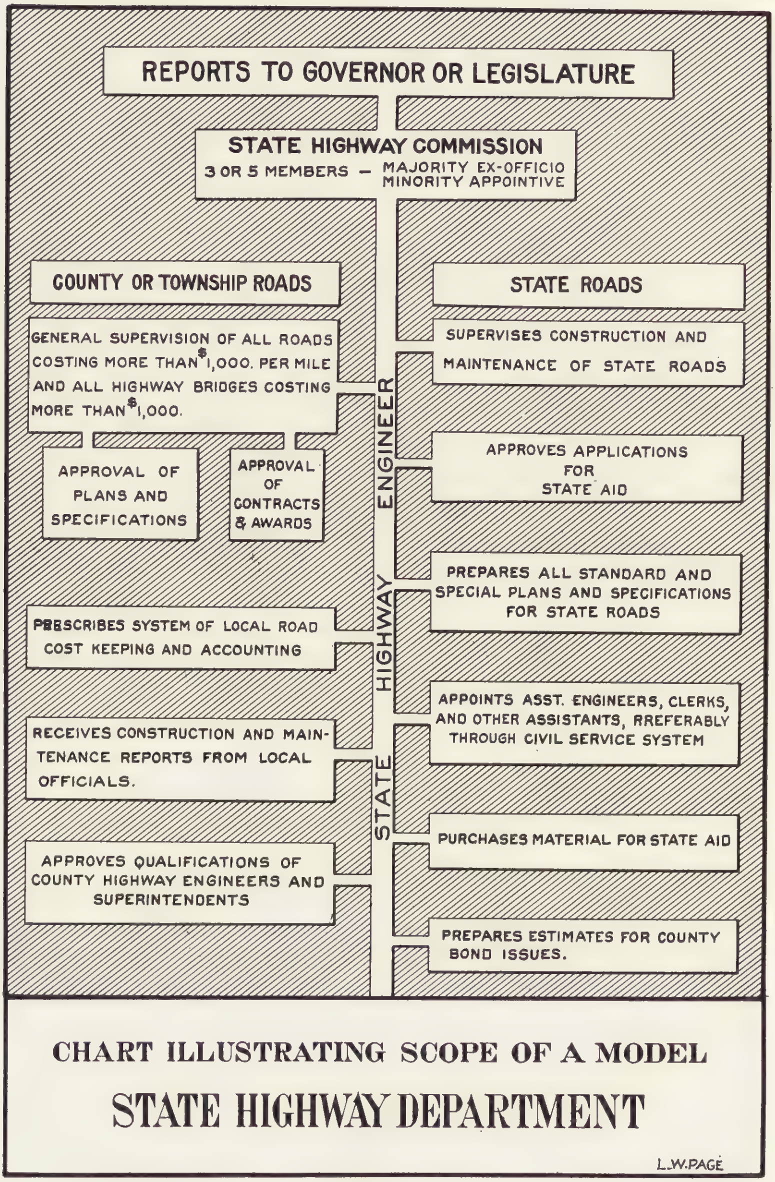

CHART ILLUSTRATING SCOPE OF A MODEL

STATE HIGHWAY DEPARTMENT

Plate II.

There are now 42 states out of the total of forty-eight which have established highway departments of one kind or another and the organizations under which these departments operate are being constantly revised and improved. This shows that the public is awaking to the advantages to be gained by having all highway work done under a scientific and comprehensive organization. There is also unquestionably a growing public demand for quantitative assurance that every dollar levied for the purpose of highway improvement is being spent to the best possible advantage, and in order for the engineer to meet this demand, he must be in a position to analyze the factors which affect the economic efficiency of improved roads and reduce his findings to a more or less quantitative rational basis. The general method of procedure necessary in order to accomplish this has already been outlined.

CONSTRUCTION.

The customary methods of constructing and maintaining the various types of improved roads are generally well understood by the engineering profession, or at least by those members of the profession who have been sufficiently interested to follow the discussions concerning highway work which are constantly appearing in engineering literature. Most of the types now in use have been developed through extensive experience, and while slight modifications in the present methods of construction will very likely continue to take place, it does not seem at all probable that there will be any very radical changes in type in the near future. It is true that a number of so-called new types of improved roads and new processes of construction have been recently developed and patented, but I think it unnecessary to consider them here.

The principal types of improved roads are earth, sand-clay, gravel, macadam, bituminous macadam, Portland cement concrete, and brick. A complete discussion of any one of these types would take up as much space as it is purposed to occupy with this entire paper, and would probably present, furthermore, only a very small amount of matter at all new to the members of this congress. It seems best, therefore, to touch only on those features of construction concerning which there has been more or less difference of opinion among engineers,

and to express such opinions regarding these features as the experience of the Office of Public Roads and Rural Engineering would appear to justify.

Plate III shows cross-sections, illustrating each type of road mentioned above, which are believed to represent the best modern practice in highway construction. It should be borne in mind, however, that no typical sections could be made sufficiently general to meet all conditions, and still be of value. Special cases will frequently arise which must be given individual consideration, if the best results are to be obtained. Some of the details shown in Plate III, furthermore, have not been universally accepted as representing the best practice, and are more or less liable to be superseded.

The amount of crown which should be given the cross-section of an improved road, for example, is a matter of very great importance and one which has been much discussed. The two factors which have had most influence in determining this detail are first, the desirability of draining water off to the sides as quickly as possible after it falls on the road, and second, the desirability of keeping the cross-section as flat as practicable in order that traffic may not be unduly encouraged to use only the center of the roadway. The character of the road surface determines which of these factors should be given most consideration. It will be noticed that in the accompanying typical cross-sections, the crown varies from a maximum of one inch to the foot for earth roads on steep grades to a minimum of one quarter inch to the foot for brick and concrete roads.

Another much discussed point relates to whether the sub-grade for brick and concrete roads should be given a flat or crowned cross-section, and it will be observed that the Office of Public Roads and Rural Engineering at present recommends the flat cross-section, especially for concrete pavements, where the width does not exceed about 20 feet. This recommendation is based, for the most part, on the fact that fewer longitudinal cracks have been observed in pavements having flat sub-grade cross-sections than where the sub-grade is crowned, and the use of such flat cross-sections adds comparatively little to the cost of the narrower concrete pavements, in which longitudinal cracks are most objectionable.

U. S. OFFICE OF PUBLIC ROADS.

TYPICAL CROSS SECTIONS FOR VARIOUS ROAD SURFACES.

W VARIES FROM 22 TO 30 DEPENDING ON TRAFFIC CONDITIONS. B (IN BEST PRACTICE) IS 10, 16, 18 OR 24 SLOPE OF SHOULDERS ABOUT 12 : 1 S SHOULD PREFERABLY BE FROM 1 TO 2 GREATER ON FILLS THAN IN CUTS

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Plate III.

Defective foundations can be corrected in a number of ways. Surface drainage is of course the first consideration, and when properly planned, is ordinarily adequate. Some combinations of soil and topographic conditions, however, render effective surface drainage impracticable, and in such cases, one of the three methods of foundation treatment shown in Plate III will usually be found satisfactory. The Telford base is especially adapted to soils which, even when well drained, are more or less unstable; the V-drain to localities where field stones may be cheaply obtained, and the side ditches to all locations where the soil is inclined to be springy or hard to drain.

Some of the other questions concerning which opinions differ are: what are the proper sizes of stone for the different courses of macadam roads, what methods of bituminous treatment are most satisfactory under given conditions, what kinds of coarse aggregate are best for concrete pavements, whether Portland cement grout or bituminous cement should be used for filling the joints in brick pavements, and whether brick pavements should be provided with expansion joints both laterally and longitudinally, or only longitudinally. The present attitude of the Office of Public Roads and Rural Engineering concerning these and other similar points has already been expressed in its published bulletins and specifications, and they are mentioned here only in order that the attention of engineers may be called to the need for collecting and assembling data bearing on the efficiency of different detail methods of construction.

MAINTENANCE.

No paper on the subject of "Rural Highways" would be complete without discussing at least to some extent, the important question of road maintenance. Scientific care in planning and constructing public roads cannot possibly obviate the necessity for maintaining them, though it can no doubt greatly assist in meeting this necessity by causing it to be fully recognized and its importance properly appreciated.

The work of maintaining public roads is necessarily more routine in character than other classes of road improvement work, and would therefore seem to be more susceptible to advantage from standardization of methods. In the United

States, however, there are discouragingly few localities in which any attempt at systematic maintenance has been made, and these are to be found only in states having strongly centralized control. In many of the states which have well organized highway departments and even those in which state aid for construction is an established policy, all road maintenance work is still being done or left undone under the supervision of the county, township or other local administrations. Judging by the annual reports of the various state road officials, however, it seems that they are practically all agreed that this arrangement is not satisfactory and are accordingly seeking to have the laws or appropriations under which they operate so changed that the work of maintaining the state-aid roads will be done under state supervision. This change has already been made in a number of states, and so far as is known, an immediate improvement has resulted.

The publications of the Office of Public Roads and Rural Engineering already include descriptions and discussions of the road maintenance systems which have been satisfactorily employed in this country and abroad, and the present program of the Office contemplates a more detailed investigation into the efficiency of the various methods now being employed. It is hoped that the results of this investigation will soon be available.

Conclusion.

In conclusion it seems fitting to pay some tribute of appreciation to the efforts of highway engineers and other public road officials throughout the country who, notwithstanding the arduous nature of their prescribed duties, are always ready to cooperate in collecting and disseminating information relating to road improvement work which might be of value to other communities, and who almost uniformly show even a broader-minded disposition in their willingness to profit by the experience of others whenever the opportunity is afforded them.

Paper No. 61

RURAL HIGHWAYS.

CONSTRUCTION AND UP-KEEP, MORE ESPECIALLY WITH REFERENCE TO AUTOMOBILE TRAFFIC.

By

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INTRODUCTION.

The Committee of Management of the International Engineering Congress, San Francisco, 1915, has requested me to prepare a paper on the Construction and Up-keep of Rural Highways. I shall therefore not consider city streets.

Although block pavement is adopted in France in many rural districts, namely in sections of intensive cultivation (for beets, as an illustration), it should not be considered as a general solution of the problem on account of its high cost. I shall therefore limit myself to certain questions concerning crushed-rock metalling, which represents by far the majority of French road-beds.

MAINTENANCE OF CRUSHED-ROCK ROADS BEFORE THE ADVENT OF THE AUTOMOBILE.

Before the advent of the automobile, the method for maintaining crushed-stone roads almost universally adopted in France was by partial, periodic repairs.

Taking a section of the road, and knowing through experience that a resurfacing, well-rolled, should last a given number of years, a resurfacing was carried out on a certain fraction of the length, of which the location varied from year to year, in such manner as to resurface gradually the entire section. Thus was established a cycle, varying from two to twenty

years, according to the traffic, the quality of the material, the thickness of the surfacing, etc., after which work would be resumed at the starting point.

This method gave most excellent results until the advent of the automobile. Practically the entire quantity of stone supplied was used in the resurfacing; in a few cases only was the stone needed on the parts of the road resurfaced at the earliest date. For this latter use, 10 percent, at the most, of the material was utilized, simply to maintain a smooth surface.

It is now shown that this method is no longer adequate with the increasing demands of automobile traffic. For this reason there has been in every direction an endeavor to either improve the method or find an acceptable substitute.

MODE OF ACTION OF VEHICLES ON A ROAD, IN THE CASE OF A PERFECTLY SMOOTH SURFACE.

The mode of action of vehicles on a road is today well known, careful studies having been made many times; I will therefore not use any formula to measure this action. Nevertheless, to support the remarks which follow, I must touch briefly upon the subject.

(1) **Normal Action**—On a road absolutely smooth, it is admitted that the action of the wheels, normal to the road, depends only on the weight, whether we consider a vehicle drawn by beast or a vehicle with motive power. The effects of this normal component must be the same in both cases. Consequently, the old methods of maintenance having been sufficient in the case of vehicles drawn by beast, one might infer that they should also be sufficient for the damage due to the normal component in the case of automobiles. However, in France at any rate, there is a considerable difference in the weight of the two kinds of vehicle. The law of 1852, regarding the police of teaming, proclaimed the absolute liberty of circulation, without any restriction in weight or in width of the tire. But, in the case of wagons with harnessed teams—the only ones foreseen at that time—this was corrected through a limitation in the number of horses. With automobiles, the proclamation relating to absolute freedom of load remains, but the indirect

fixation of a maximum of weight, through the number of horses hitched to the team, is no longer applicable. Therefore some automobile manufacturers have put on the market vehicles of such a weight that the best pavements have not been able to resist. Today, this exaggerated abuse hardly continues; automobile manufacturers are conforming themselves, in general, for the maximum weight, to the conclusions formulated by the Road Congress of Brussels.

However, it is accepted that the load of heavy-weight automobiles still exceeds to a great degree that of vehicles drawn by teams.

This action, due to the weight, is made manifest at first by the crushing of the materials which constitute the road, if they are not sufficiently resisting. In addition, when the empty spaces between the stones are filled by debris without sufficient cohesion, either in the case of extreme dryness or in the case of extreme dampness, the filling no longer constitutes a real concrete, the road presents no resistance in its entirety, each stone being isolated from its neighbor. The circulation of heavy-weight vehicles causes then a certain sliding of the stones one over the other; they wear off in this rubbing and crush separately under the load. The road, instead of being formed by material of the proper size, gradually becomes made up of stones of constantly decreasing size, constituting at the end little more than a mass of mud and dust.

For this there are only two remedies: The use of hard and non-breakable material and of a binding with such a cohesion that the road is in its entirety a real concrete, capable of resistance; or else, the use of a binder such that if it loses accidently its cohesion, it is able to regain it anew, either through the simple action of atmospheric agencies and of travel or through some inexpensive operation.

(2) **Tangential Actions**—If we still consider the case of a perfectly smooth road and take up the tangential component of the action of vehicles on the road, we are led to note the main differences which exist between the case of traction by beast and that of automobile traction.

We consider first the absolute magnitude of this component. Referring to traction by beast, it is always of the same

magnitude, in relation with the load and the resistance to rolling. It is influenced neither by declivities nor by acceleration, nor even by speed. In fact, the effort of traction exercised by the beast is directly applied to the vehicle itself. It directly balances either the component of the weight parallel to the road in case of a grade, or the force of inertia due to acceleration, or the air resistance opposed to the movement. If then the effort of traction exercised by the draft animal is influenced by these various circumstances, the tangential reaction on the road, on the other hand, is not at all modified by them. The movement of the wheel is always a kinematic rolling, almost perfect.

Regarding traction by motive power, the case is quite different. Here the progression of the vehicle is solely due to the tangential component which is being considered, so that the latter must balance, aside from the resistance to the rolling, either the component of the weight parallel to the road in the case of a grade; or the forces of inertia due to an acceleration; or the air resistance, which is proportionate to the square of the speed. The great difference between the two cases is thus readily seen. No vehicle drawn by beast can tear the road (leaving aside the case of braking, which I do not consider); the driving wheels of the automobile, on the contrary, can easily assume, and do often in effect assume, under the influence of the driving couple, a movement of rotation which produces along with the rolling itself a superficial sliding, very damaging especially with non-skid tires.

If we consider the direction of the tangential action now before us, still in the case of a perfectly smooth road, the difference between traction by beast and by motive power is still greater.

With traction by beast, the tangential action of the wheel of the road is always directed in the direction of the movement. In the case of the driving wheels of automobiles, this tangential action is directed inversely.

It is then easy to understand that the circumstances change completely in passing from one case to the other.

Let us consider, by way of illustration, that a wheel passes over a fragment detached from the roadbed. With traction

by beast, the fragment is always urged in a forward direction, and even then the action is weak; it tends consequently to maintain itself under the wheel after its passage: with traction by motive power, the effect of the driving wheel exercises on the fragment an action which drives it towards the rear and frees it in a manner from the wheel in the inverse direction.

This observation becomes very important with elastic tires such as pneumatics. If the tangential action of the wheel on the road assumes a definite direction, the reaction of the road on the wheel, which equals it in absolute value, is in direct opposition to it. We conclude that, with traction by beast, the road draws the tire tangentially in a direction the inverse of the course, while, with traction by motive power, this action is exercised in the direction of the course. Because of the elasticity of the tire, there takes place, at the point of contact with the ground, a slight deformation which thrusts the tire towards the rear in the first case and towards the front in the second case. When the wheel turns, the point of contact with the ground changes at every moment, and the deformed tire, on leaving the road, tends to resume its normal form. It returns forward with traction by beast and rearward with traction by motive power. In the first case, the isolated fragment, mentioned a moment ago, has therefore a marked tendency to come back under the wheel, whilst in the second case it is projected more or less violently towards the rear.

Aside from the consideration of the case of isolated fragment, we must remember that the tangential action is much more violent in the case of automobiles, and that in addition there often takes place a scraping capable of attacking the materials of the aggregate which fills the empty spaces between the stones. The result of this destruction, detached from the road, is then projected towards the rear.

These facts bear out the observation which everybody has made regarding the numerous clouds of dust that the driving wheels of automobiles produce, especially when they are going at high speed.

Without further insistence and without speaking of other special damages, as for instance on curves, it is readily seen how automobiles carry out their destructive action, even on

smooth roads, the only ones considered thus far; while, on the other hand, vehicles drawn by beast produce only unimportant results.

This is why the smoothness of the surface soon disappears, We must therefore take into account new effects which result from the appearance of projections and depressions.

MODE OF ACTION OF VEHICLES ON ROADS IN THE CASE OF A SURFACE NOT ABSOLUTELY SMOOTH.

When the road is absolutely smooth, the movement of the wheels is a continuous rolling; that is to say, the instantaneous center of rotation at the point of contact of the wheel and of the ground displaces itself, as well on the wheel as on the road, occupying in succession every point of both without solution of continuity. As soon as the smoothness disappears, however, it may happen that the wheel, meeting a projection or a depression or even a solution of continuity in the road, comes into contact with the ground by passing violently from one point to another of the circumference separated by a finite distance. The instantaneous center of rotation passes thus instantly from one point to the other of the road, the distance of which we will express by the letter a. At that moment, a shock takes place.

If we designate by W the weight of the part of the vehicle which is not suspended by the springs, by V the speed of the vehicle, and by R the radius of the wheel, the *vis viva* lost by this shock will be represented by the expression:

$$\frac{W}{g} \frac{V^2}{R^2} a^2$$

If the case of a very marked projection or depression presents itself, the height or the depth being h, this expression of the *vis viva* lost is transformed into:

$$\frac{W}{g} \frac{V^2}{R} h$$

Finally, if we consider only the mean supplementary effort of traction that this resistance causes to the motor, and without taking into account the work due to gravity which is capable of compensating itself by the successive ascents and descents, it would suffice to consider the quantities:

$$F = \frac{W}{g} \frac{V^2}{R^2} \Sigma a^2$$

$$F = \frac{W}{g} \frac{V^2}{R} \Sigma h$$

Σa^2 or Σh being the sum of the terms a^2 or of the terms h, ascent or descent, corresponding to the obstacles that the wheel may meet, on an average, on a unit of length.

As we are not considering here the calculation of the power of the motor, but the real and effective action of the wheel on the pavement, we have to consider separately what takes place, first, at the very moment of each one of the shocks and during their duration, then immediately afterwards.

In the case of a vehicle drawn by beast, each one of the shocks brings to bear against the obstacle a forward pressure corresponding to the lost work just calculated. For instance, if we have to consider a projecting stone, this stone will at first be subjected to an instantaneous pressure in the direction of the movement, producing a momentary decrease in the speed, a decrease which will be regained after the shock through a supplementary effort, the average value of which was given above. In the hypothesis of traction by beast, this effort, which corresponds to the acceleration to be produced, has no influence on the magnitude of the tangential action of the wheel on the pavement; furthermore, after the shock this tangential action always maintains its direction in the direction of the movement.

In the case of an automobile the circumstances change completely. Each one of the shocks naturally causes, as in the preceding case, a percussion against the obstacle in a forward direction. This percussion corresponds to the lost work. After the shock, to resume the speed through the supplemental effort of the motor, noted above, a corresponding acceleration has to be created. With the automobile, the greatness of the tangential effort exerted by the wheel on the ground is notably influenced by this acceleration,* furthermore, what is more serious, its direction is always contrary to that of the movement.

It may be seen, by this outline, how a projecting stone on which the wheel exercises a limited action and always in the

* It is proportionate to the square of the speed, and to the weight of the non-suspended part of the vehicle.

same direction before as well as after the shock, may very well resist displacement in the case of a vehicle drawn by beast, whilst in the case of a mechanical traction with the alternating actions in contrary direction, and also much more powerful, it must necessarily be loosened and projected outside of its alveole.

The illustration just given of the projecting stone could be adapted to all other cases bearing on a solution of continuity in the rotation of the wheels; therefore, it does not appear necessary to insist further on this point. These considerations will therefore explain the destructive action peculiar to automobiles as soon as the smoothness of the surface has disappeared.

It must be admitted that automobiles provided with pneumatic tires roll rather easily, a fact which is due to the continuity of rotation being insured, especially when unimportant obstacles are met. This is explained in France by the picturesque expression, ''the pneumatic absorbs the obstacle''. But in addition to the fact that the tire no longer absorbs the obstacle when the latter exceeds a certain order of magnitude. it loses the advantage of its mode of action on the ground. In attacking the obstacle, the inflated tire presses it forward, but in leaving it, it thrusts it backward. If the action is decreased during the first of these operations, it is augmented during the second on account of the elasticity of the tire which contributes with great force to throw backward the part of the pavement it has succeeded in loosening.

What precedes can be summed up by stating that the less smooth the road, the more sensitive it is to the destructive effect of the traffic, and especially of automobile traffic.

To this discussion, we should add to the above some explanation to show how a road, even when smooth but presenting undulations of a rather limited amplitude, is placed under conditions infinitely less favorable than those which present a rectitude of profile absolutely satisfactory. But this would carry us too far, and if reference is made to the matter, it is only to point out that the rolling of the road must be very carefully carried out to avoid these undulations.

ACTUAL EFFECTS OF AUTOMOBILE TRAFFIC ON PAVEMENTS.

Without mentioning the highways subjected to an exceptionally intense automobile traffic, and in which no stone metalling laid according to the old methods is capable of resistance, we shall limit the discussion to the roads, far greater in number, which are subjected to a heavier traffic than before and of a new kind, but for which the radical transformation would create expenses out of proportion to the general interest at stake.

On these pavements wear and tear is brought about in two ways.

(1) Isolated holes which occur even on new surfacing, and which appear usually in a rounded shape, from which shape they get, before they are considerably enlarged, the name of hen's nest. These holes, which originate in the wearing off of the surface by automobiles, are scattered irregularly over the road; in many cases they increase in number very rapidly and at any season of the year, in such a way that a pavement, often of excellent quality in the beginning of the season and still covered with a normal thickness of stone, becomes suddenly riddled with holes, in no wise analogous with the classical form, and which render the rolling very difficult and in addition contribute to increase the disintegration by the shocks which result.

When close observation is made on pavements broken up in this way by automobiles, it may be seen that the holes characterizing this sort of wear are found in large numbers on certain zones of the pavement, whilst neighboring zones placed under the same conditions from the point of view of their material, of their foundation, of their composition and of their traffic, resurfaced at the same time, with the same materials and in the same way, remain absolutely intact.

Since certain parts of the pavement could resist when others were yielding, without any external reason with which to explain the fact, the conclusion must be drawn that there are hidden differences between the zones under consideration—differences which can only result from local imperfections brought about through a lack of homogeneity in the surfacing,

which allows the automobile wheels to attack certain weak spots with success.

As it is certain that the pavement which resisted on large stretches, as is frequently noticed, would have resisted likewise in the neighboring zones if these had been identical, it is evident that one of the most important features in road repair is to overlook no detail of execution which may tend to insure perfect regularity in the work and the establishment of a homogeneous wearing surface. On account of the new circumstances which confront us, everything becomes of vital importance; homogeneity in the quality of the stone, absolute regularity of break; uniform spreading before beginning the tamping; homogeneity of the aggregating material employed; absolutely equal distribution of this material on every point; methodical watering and tamping, etc. It appears then quite evident that if perfection could be approached on all these points, we might struggle efficiently against the wear and tear of automobile traffic.

Outside of these local breaks which are peculiar to automobile traffic, there are those which, as stated above, result from the disappearance, through wear, of stretches more or less improved, of older surfacings. These breaks are noticed in the surface shortly before reaching the limit of duration. The local breaks or holes no longer show their peculiar form; their outline is cut out irregularly.

In such a case, before the advent of the automobile, it was possible, with temporary repairs, to await the time for the regular repair called for by the program of up-keep for the roads.

Today this delay is no longer possible. It is noticed that as soon as the pavement shows its weakness through holes of this kind, it passes almost immediately from a fair condition to one of ruin, without even maintaining itself for a period, however short, in a mediocre condition. This is due to the intense action of the automobile on the pavement when meeting the obstacles.

There is no other remedy in this case than to suppress the cause of the evil by reestablishing, temporarily, the smoothness of the surface. In doing this, traffic will be facilitated, the

road will be cleaned out and therefore less subject to absorption of moisture, and, finally, the ground will be prepared to receive the next re-surfacing.

MODIFICATION OF THE MODE OF UP-KEEP.

We may leave for a moment the quality required in the road metalling and in the binding material to be placed between the stones, and consider briefly the necessary changes which must be developed in the program of maintenance through periodic repair.

Regarding holes of first class, since we have here to consider holes which appear at a given moment, then enlarge very rapidly, it is of vital importance to correct them at the very moment they appear; and in all cases, as soon as possible after their formation. We thus reach, for repairs of this kind, the following simple rules:

(1) To prevent, as far as possible, the formation of holes
(2) To repair immediately each hole as soon as it is formed.

As the appearance of each one of these round holes results from the wearing off of the pavement by the automobile traffic and from the correlative dispersion of the aggregating material, we can struggle effectively against the evil only by fixing this material between the stones by every means which may be devised, or better still, by adopting at the start a binder which, through its own nature, may either resist effectively the attack of the wheels or recover by itself its power of resistance, if perchance it has lost it.

As for the repair of the holes, it has already been stated that it should be immediate, so that the disorder will not be soon beyond repair. We may add that these repairs should be such that in place of the cavity a refill should be placed, as nearly identical as possible, from all points of view, with the material of the road which surrounds it. In only one way can this be done, viz., by taking out completely from each hole whatever remains of the material which could not adhere to the mass, and replacing it by other material in conformity with the conditions stated above. It is not sufficient, in this case,

to spread out the stone and expect the traffic to effect a bond; it is absolutely necessary, giving the closest attention to the composition of the stratum to be laid down, to clean out and water beforehand the cavity, to distribute methodically the material, to water and tamp them until completely bonded, endeavoring at the same time to cause even the external appearance of the repair to disappear.

By means of the efforts above outlined, it may be understood that it is possible to maintain a road according to the old methods, but a second modification is to be recognized for the repair of surface holes caused by wear, when a surfacing is reaching its limit of effective service.

It has been stated that at a certain time a mediocre pavement may become suddenly bad, even to the point of being ruined, at short notice. The cause of the trouble comes from the disappearance of the smoothness of the surface. As the time has not yet arrived for a general repair of the road, and as, furthermore, the necessary resources are not at hand, the situation can only be met by reestablishing temporarily the smooth surface by filling the holes with a limited though sufficient amount of material, so that after the rolling the pavement may resume, if not its normal profile, at least a regular one. These repairs, by reestablishing the smoothness of the road, produce very beneficial effects. The drainage of the surface waters is insured, the pavement remains compact and can resist the normal and tangential efforts of the wheels. Furthermore, the road is thus prepared to receive the regular resurfacing which is to take place at the end of the period.

By reason of inability to apply the principles which have been presented, roads have been allowed to become entirely destroyed. First, the smooth surface disappears, then the cohesion. The stones wear off and are crushed separately, their size decreases steadily, and the road soon constitutes nothing but a mass of mud or dust, in which are found here and there a few isolated stones. When such a serious condition of affairs has been allowed to develop, a simple repair is not suitable, although the ground may still appear capable of offering a certain resistance. Experience seems to demonstrate, today, that it is very desirable to give the ground the homogeneity it

lacks through the mechanical breaking up of the pavement, which facilitates the elimination of all the harmful debris.

SUPPLEMENTARY OBSERVATIONS ON MATERIALS AND BINDERS.

We have already seen that heavy automobile traffic calls for the use of materials resistant enough not to crush or break under the weight. It was furthermore noted that the spaces between the stones should be filled with a material presenting and maintaining a cohesion such that the pavement would form a concrete monolith. It was also pointed out, on the other hand, that swift automobiles tend to disorganize the pavement, chiefly through their action on the aggregating material (binder) which they destroy and scatter in the shape of dust. They contribute thus to the separation of the materials and finally to the loosening of the stones in the weak spots. The conclusion was reached that it is necessary to build up the pavement with homogeneous materials, not only in regard to the quality and the size of the crushed rock, but also in regard to the quality, homogeneity and equal distribution of the aggregating materials. It therefore follows that to determine upon the mode of construction of a pavement, it is necessary to know beforehand the nature and importance of the traffic on the road and then to examine what resources are available in the neighborhood.

The most essential qualities to be considered in the crushed rock are the following:

Resistance to crushing action
Resistance to the shock
Resistance to wear by reciprocal friction
Homogeneity
Rock capable of breaking regularly and uniformly
Rock which under the influence of rolling or of ordinary traffic may give fragments more or less capable of forming a binder for the larger pieces.

The qualities of the aggregating materials (binder) which should be considered are the following:

Permeability or impermeability
Material capable of becoming more or less coherent

Material capable or incapable of becoming again coherent when cohesion is destroyed

Elasticity, etc.

It is realized that it is impossible to cover the ground completely. It will be sufficient to here state that in many cases fairly satisfactory results are obtained even with calcareous materials which are not very hard, if they yield, in breaking, a debris capable of forming a suitable binder. In other cases, materials of an exceptional hardness must be used; the greatest difficulty in such case, especially when the small fragments will not furnish a coherent aggregating material, is to find a suitable cheap binder.

Most of the researches thus far have been made in the direction of the utilization of bitumen or tar. Special mention of these is not needed here, chiefly because there is little new in that line. Furthermore, in France, leaving aside surface oiling, which has been used widely but not on any great scale, trials of pavements with various binders formed with bituminous or tar substances have only been carried on in the cities or in departments neighboring the capital. On the other hand, reference may be made to trials which have been made in certain places in the region of the east of France with very hard materials, not possessed of great binding qualities, coming from the quarries of trap rock situated at Raon l'etape in the Vosges.

This material is among the best from the point of view of resistance to crushing, to shock and to wear; it breaks well, is homogeneous but does not bind easily.

Mr. Ramu, who is the author of these trials, has undertaken to solve the following problems:

(1) To find a binding material which would be capable of binding the crushed rock so that the pavement will form a monolith comparable to concrete;

(2) This result having been obtained, and admitting that the cohesion was destroyed momentarily for any given cause, to find a binder capable of reconstituting itself indefinitely and therefore of regaining rapidly the lost cohesion.

What is required in following this order of ideas is to obtain a perfect bond, not through a rigid mortar, such as

those made with lime, cement and sand and which, once broken, dislocated or crushed, are unsatisfactory for any new use, but rather a flexible mortar with indefinite capacity for recovery, indispensable for materials which are to be subjected to constant efforts tending to displace, break or crush them, and not indefinitely immobilized as in the case of masonry.

Silicious sand would not be satisfactory, for it does not bind. The pieces of crushed rock, even after an energetic rolling, continue to wobble unless they are crushed and through hazard from this crushing, some fragments are made which afford a certain bond. But this does not happen for materials as hard and silicious as trap rock; even then it is unreasonable to crush the rock which is bought at a high price in order to transform part of it, at the expense of solidity, into a binding material which may be obtained with more economy.

As a result of experiments which have been carried on, binding materials presenting in different degrees the required qualities are found almost everywhere; either in the form of soils of various kinds, the products of decomposition or erosion of igneous or sedimentary rocks, or in the form of fine and muddy sediments which may be drawn out of rivers or quarries (excluding fatty substances), which, under certain conditions, after being crushed by the roller, may give the appearance of a binder, which is only temporary because the fragments of stone strengthen it in an insufficient and precarious manner.

According to Mr. Ramu, it is the proportion of hydrated silicate of alumina (colloidal clay) which characterizes the essential property from the view-point of action as a binder.

Colloidal clay must not be confounded with ordinary clay, which can contain only a very small proportion of the first-named. Furthermore, the material to be used should not contain too much hydrated silicate of alumina, for, if in excess, the kneading of the material would be impracticable in the case of a surface distribution, and the penetration into spaces between the stones would not take place.

Without giving here the laboratory work carried out by Mr. Ramu in examining the materials to be used, a very simple experimental method may be pointed out which permits of

ascertaining if a material answers properly the desired conditions. He takes 100 grammes of the binder, mixes it with 15 to 25 grammes of water, or more according to the case, and then kneads it in such a way as to obtain a paste which settles of its own accord.

He then pours this paste into a saucer and brings about a leveling on the surface through moderate shaking. The mass is then exposed to the air in order to bring about a slow desiccation. These operations concluded, the next thing to be ascertained is if the material has or has not transformed itself into a mass of free grains, more or less aggregated, as in the case of clean, sharp sand, or into a compact mortar, relatively hard and as free as possible from the cracks resulting from desiccation. To ascertain the resistance, it is sufficient to cut the contents of the saucer into two parts. One is thrown out of the saucer and the other is kept. In the middle of the edge thus formed by the knife, the lump is pressed with the thumb.

If the disk was not cracked in drying, or only slightly, and if, furthermore, the edge resists this pressure, Mr. Ramu then concludes as a result of his experiment that a pavement of trap in which this material is used as a binder will present neither loosening through protracted dryness, nor violent tearing away from the skidding of automobiles; but under the express condition that the material should be used in sufficient quantity.

The experiments carried out regarding the resistance of this material after its hardening have proven that a resistance to breakage can be obtained which is not very different from that of certain mortars of hydraulic lime.

But, and this is the main point, the difference which exists between this binder and a mortar of lime is that it reconstitutes itself if, through a given series of circumstances, it had lost its cohesion.

Regarding the quantity of binder to be used, Mr. Ramu bases his opinion on the volume of the spaces between stones after tamping, spaces which the binding material must fill completely. However, the swelling of the binder, in passing from the powdery condition to the pasty, must be taken into account, as well as the contraction which is produced in the

opposite direction by the subsequent desiccation. These are two factors which cannot be easily gauged. Mr. Ramu obtained good results with a proportion of 0.25 cu. m. (8.82 cu. ft.) of binding material, with the judicious use of 350 litres (92 gal.) of water, all for one cubic meter (35.29 cu. ft.) of trap rock for a surface of from 0.07 m. to 0.08 m. (2.75 to 3.15 in.) thick.

All the experiments of Mr. Ramu appear to have been carried out with the greatest care, at the same time paying the closest attention to the details of the organization of the road repair plant. Space does not permit the discussion of these operations in detail, but mention of them should be of interest, since they might be used as a starting point for new attempts. In any case, while they do not supply us at present with a complete solution of the problem of a water binder, they seem to suggest the way to a solution in a rational manner.

Paper No. 62

CONSTRUCTION AND MAINTENANCE OF RURAL HIGHWAYS.

By

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The Author's practical experience in the construction and maintenance of roads has been entirely gained in England. During the past 25 years he has been successively Assistant County Surveyor of Kent, and County Surveyor of Herefordshire, Wiltshire and Surrey. The first and last Counties are suburban in parts bordering on the Metropolis; the two intermediate Counties are almost entirely agricultural. During the 6½ years the Author has been in Surrey the automobile traffic has immensely increased and now forms by far the larger percentage of the traffic. In some cases the horse-drawn vehicles only amount to 13% in number and 7% in weight of the total of the two kinds of traffic.

As weather influences form such a large factor in the durability of all kinds of road surfaces, it is desirable that Congress should be reminded of the conditions that obtain in this country. The average rainfall varies in different parts of the country from 20″ to 35″ (50-88 cm.) but rises to about 75″ (187 cm.) in the mountainous portions. The general average over the greater part of the country is probably round about 28″ (70 cm.); measurable rain falls on about 180 days in the year, there being a large proportion of days when the roads remain damp in consequence of the humidity of the atmosphere. The roads are generally bordered by hedges and trees which tend to encourage dampness by excluding sun and wind.

The temperature ranges from 135° Fahr. (57.2° C.) maximum sun heat on road surface to a minimum of about 14° Fahr.

(-10° C.) or a range of approximately 120° Fahr. (48.8° C.). Hard frosts are seldom of long duration, but for the 5 months from November to March morning frosts and subsequent thaws, often attended by slight rain, bring about very unfavorable conditions for maintenance. At rare intervals frosts of several weeks' duration are experienced, but for the last few years the winters have been of a generally mild character.

For the better understanding of English conditions the Author desires to point out that owing to the very complete network of highways existent in all parts of the country there is very little new construction of rural roads, except such as arises from the development of new centres of population. Almost all the main traffic arteries consist of the old turnpike roads which were either newly formed between 1730 and 1840 or improved from previously existing highways during that period. The general formation of these roads consists of an aggregation of gravel or broken stone on the natural soil, except in districts where granite, limestone or sandstone rocks prevail, where pitched foundations obtain. The thickness of the crusts varies considerably according to the nature of the subsoil and the traffic conditions to which they have been subjected, but in general terms they may be said to range from 6″ (15 cm.) on chalk and dry gravel to 15″ or 18″ (37 cm. or 45 cm.) on the clay and other wet soils. Where pitching exists it ranges in thickness from 4″ (10 cm.) to 9″ (22 cm.). From a considerable experience of maintenance on both kinds of foundation the Author prefers for general stability the pitching method to the macadam aggregate, although, with adequate side support, the latter is found to afford a quite satisfactory base for all but the very heaviest traffic conditions.

The district or branch roads are very similar to the main traffic arteries except that pitching is seldom found, as their growth from tracks to hard metalled roads has been of a more haphazard character than in the case of the old turnpikes, and the thickness of road crust is seldom as great.

CONSTRUCTION OF RURAL HIGHWAYS.

Very little change has been made in recent years in the methods of constructing new roads except to provide a some-

what greater depth of foundation. The general practice after grading the soil bed is to lay "hard core" composed of old concrete, hard burnt brick rubbish, or rubble stone, and consolidate by rolling to the required thickness which ranges from 6″ (15 cm.) to 12″ (30 cm.) according to the nature of the subsoil and the traffic to be expected. The former thickness is often considered sufficient on chalk or dry sand or gravel, and the latter is used on clay and wet soils where the bottom 3″ (7.5 cm.) is often composed of ashes which are found useful to form an absorbent base and to prevent clay from being squeezed up among the hard core in the process of rolling.

Where clean ballast is available at a reasonable price it would probably be found cheaper to form a Portland cement concrete base, and in the Author's opinion the tendency will be in that direction. In suburban districts this has been done in a few cases and quite recently some reinforcement of the wire mesh type has been used. The concrete method of foundationing is in the Author's opinion preferable to the hard core method where a tar-macadam or bituminous paving is to form the surface provided a sufficient thickness of pavement is laid to permit of some resilience.

For waterbound surfaces 6″ (15 cm.) is the usual consolidated thickness of metal imposed upon the foundation course; the bottom 3″ (7.5 cm.) being generally of an inferior material to the wearing surface.

Nearly all newly formed waterbound roads are now surface dressed with hot tar and chippings or coarse sand on completion. Two dressings are generally given the first year and one in succeeding years during the life of the coating.

For roads required to sustain a great deal of motor traffic, tar-macadam is generally used for the surface, in which case the thickness is not less than 3″ (7.5 cm.) but preferably 4″ (10 cm.). The most satisfactory material for the purpose is blast furnace slag as it has the property of forming a homogeneous mass, retains its life, and forms a very waterproof and durable wearing surface. The gauges generally employed are 2¼″ (5.5 cm.) for base, 1½″ (3.75 cm.) to ½″ (1.25 cm.) for topping, with a little ½″ (1.25 cm.) as filling material. An alternative method is to lay the main coating of mixed

grades from 2¼″ (5.5 cm.) down to ½″ (1.25 cm.) with a little ⅜″ (0.95 cm.) to fill the voids. For 3″ (7.5 cm.) pavements the Author prefers this method, but for 4″ (10 cm.), the former.

Limestone tar-macadam on the same system of laying has been largely used and where the situation is well exposed to quick-drying influences, has been found very successful, provided the traffic is not too heavy.

Granite tar-macadam has also been largely used but the results on the whole have not been satisfactory, the failures far exceeding the successes. It is far more susceptible to sun heat than the slag or limestone, permitting considerable movement under heavy wheels in summer, and it is far from waterproof in winter. Its use in any but exposed situations and under quite light traffic the Author considers will lead to disappointment; at any rate that has been his experience based on a great variety of instances.

To a very limited extent, pitch-grouted granite has been used as an alternative to tar-macadam, but the tendency to corrugate in hot weather is a great drawback to this method of construction. In the Author's opinion, this is due to the excessive amount of matrix used to fill the voids, notwithstanding which, it is difficult to secure complete waterproofing in Winter, and an irregular texture of surface is often experienced in consequence of a perfectly regular distribution of the matrix not always being obtained. The Author ventures to suggest that the method is crude in its execution and uncertain in results and will not survive in the march of progress.

Another method adopted more particularly in districts where horse traffic is in the ascendant and on steep gradients is the use of binders for macadam of the nature of slow-setting cements such as Rocmac, Ferromac and Vianex. These meet with considerable favour in the Midlands and the North, and undoubtedly serve a useful purpose in holding the material firmly in place, thus lengthening the wear of the macadam. The road produced is however by no means free from dust, and palliatives have to be used where the automobile traffic is appreciable.

For the heaviest class of traffic and particularly on bus

routes double course pavements consisting of an asphaltic or bituminous binder course carrying a carpet coat of asphaltic material are used. The durability of this form of construction is expected to be great. The drawback appears to be the liability to slight surface corrugations of the nature of short waves or ripples.

WIDTH OF CARRIAGEWAYS.

There is a general tendency to increased width as it is found desirable to enable the traffic to distribute itself over the full width of the road.

Taking the English Road Board Forms as a basis for instances of traffic the following widths are found the most suitable for main arteries in country roads.

Up to 3500 units per day of 16 hours (approximately 170,000 tons per yard width per annum) 30 ft. (9.12 metres).

Up to 2500 units per day of 16 hours (approximately 150,000 tons per yard width per annum) 24 ft. (7.29 metres).

Up to 1000 units per day of 16 hours (approximately 50,000 tons per yard width per annum) 21 ft. (6.38 metres).

Up to 700 units per day of 16 hours (approximately 38,000 tons per yard width per annum) 18 ft. (5.47 metres).

The Author is strongly of opinion that the latter width is the minimum required for any considerable automobile traffic but for branch roads carrying only a small amount it may be reduced to 14 ft. (4.25 metres). Narrow carriageways tend to undue wear by tracking of the centre portion, a form of wear which it is very difficult to satisfactorily repair.

CAMBERS.

The latest practice in this respect is to keep the cross fall as little as possible, to enable the full width of road to be used. Cross-falls range from 1 in 28 to 1 in 36 according to the relative smoothness of surface of the coating material, the latter grade being used for asphaltic surfaces.

MAINTENANCE OF EXISTING HIGHWAYS.

In this country, with its complete network of roads existing before the advent of self-propelled traffic, the question of maintenance has always been the most important one, and has

resulted in many progressive changes. From the passing of the first Motor Car Act in 1896, legalizing the lighter form of self-propelled vehicle, there was a steady but slow growth of this kind of traffic but it did not become sufficiently great to cause any extensive trouble until about 1903 when tracking, potholing, and general disintegration of surface became a serious factor and the dust nuisance caused a great outcry. This led to the adoption of surface treatment with tar and similar compounds which undoubtedly resulted in the practical abolition of the dust nuisance in its acute form and also in its result lengthened the durability of the waterbound coatings. Up to the present day, on sound crusts in fairly dry situations, a waterbound macadam road surface tarred each year is found to be the most economical and satisfactory form of road where the traffic does not exceed a maximum summer traffic of about 1300 units or say 1200 tons per day and a winter traffic of about 60% of this maximum on a 20 ft. (6 metres) width of carriageway. In a situation which is permanently damp throughout the winter months this limit may prove somewhat too high to give satisfactory results as, ere the Winter is over, the tarred surface becomes practically destroyed and before the weather becomes sufficiently dry to enable re-tarring to take place the disintegrating effects of traffic on the damp surfaces are rapid. This is particularly so if there is any large proportion of rubber-tyred heavy vehicles such as motor busses or lorries.

The general tendency of road maintenance on rural highways during the last 10 years has been to change the surfaces in the following order according to the severity of traffic conditions.

1. Substitution of the hardest granites for limestone and flints on waterbound roads.

2. Surface tarring.

3. Tar-macadams composed of blast-furnace slag, limestone, and granite and cementitious binders such as Rocmac, Ferromac and Vianex or pitch-grouted granite.

4. Asphaltic carpet coats 1″ to 1½″ (2.5 cm. to 3.8 cm.) in thickness on existing waterbound macadam base.

5. Two-course pavements of tar, pitch or bituminous macadam base with 1″ (2.5 cm.) carpets of asphaltic facing material thereon.

The large growth of the heavier class of motor vehicle such as the 5-ton lorry, the busses, and delivery vans, during the last 3 or 4 years has rendered the difficulty of maintenance much greater. When these units reach an appreciable proportion of the traffic waterbound macadam, even if surface tarred, soon becomes distorted, and its renewal is practically impossible as new coatings are corrugated before the water used in consolidation has dried out. The two-course pavement with asphaltic carpet is now being largely adopted on important roads to meet this condition, and especially on country motor bus routes. One-course asphaltic macadams have been tried but in few cases have they had a long life under heavy traffic as the winter traffic tends to unseal the surface to some extent and gradual disintegration follows.

Some of the county councils and the larger-town authorities have recently established their own plants for the manufacture of bituminous macadams and asphaltic carpets. Among the chief reasons instigating this departure was the difficulty of getting repairs, such as small patchings and trenchings, well made at a reasonable price. In many cases too, there are local supplies of suitable sands available which can be utilized in the manufacture of asphaltic materials and conveniently distributed from local centres by means of petrol driven motor lorries. Moreover the men engaged in this work can be found employment during the winter months on other work in connection with roads, an advantage which is not always open to the contractor, who either has to retain men whom he cannot profitably employ or run the risk of losing them when the season for asphaltic work comes round again. It is expected that the larger authorities will be able to effect a considerable reduction in the cost of paving works for these reasons.

The lateral retention of road crusts has, during the last year or two, become a pressing question owing to the heavier vehicles largely keeping to the sides of the roads to avoid the continual pulling in for faster vehicles to pass. On country roads bordered only by grass margins it has been found that

the crusts tend to push out into the margin. Such margins have always proved an unsatisfactory finish for bituminous coatings and this has led to the more important lengths being kerbed with granite kerbs bedded on concrete. The Author has lately adopted a continuous reinforced in situ submerged concrete kerb for the purpose of affording support to road crusts where bituminous pavements are being laid. These kerbs are of a minimum depth of 9″ (22.75 cm.) and width of 4″ (10 cm.) and are reinforced with two rows of ¼″ (.63 cm.) steel rods. The top edge of the kerb is set at the proper level to form the abutment to the face of the asphalt or tar-macadam coating. With cement at 38/- ($9.12) per ton, ballast about 7/- ($1.68) and labor averaging about 4/6 ($1.08) per day the cost complete works out at about 18d (36 cents) per yard run or the equivalent on an 8 yd. (7.3 metres) width of carriageway of about 5d (10 cents) per yard super.

The Author suggests this method of retention is particularly valuable where the road consists only of macadam aggregate without any supporting pitching or thrust blocks.

Small Repairs.

The Author finds that prompt and skilful attention to small surface repairs is becoming more and more important as automobile traffic increases. It is most necessary, to secure the prolonged life of pavements.

In this country, it is customary to have what is known as a "lengthman" who has charge of from 2 up to 5 miles (3.2 km. to 8 km.) according to the importance of the road. His duty is to keep his length neat and tidy, and execute small patching repairs directly a slight defect appears, for which purpose he is kept supplied with suitable patching materials. All patches have to be neatly cut out to a sufficient depth to permit of a proper key being obtained and the material is consolidated with a rammer or hand roller.

DISCUSSION

Mr. T. Warren Allen,* M. Am. Soc. C. E. (by letter), desired to first call attention to the matter of design. Mr. Allen.

The function of a highway is to promote the well-being of the commonwealth, and it should be considered not only as a way over which produce is carried to market, but as a means of promoting social efficiency. Our people spend considerable time in traveling to and fro, and our highways should be so designed that they may be able to do this not only easily and comfortably but also enjoyably. Therefore, we should lay out our highways so that they shall be smooth, direct, with very easy gradients, and bring into view the features of natural beauty.

Rural highways are built to carry traffic; and that they may efficiently do this, there must be a traffic determination, not only of kind and amount, but of direction, and an attempt must be made to estimate future traffic in character, quantity, and direction of movement. The determination of character and quantity are necessary in order to fix upon the type of road to use and its width; knowledge of direction of movement will enable the routing of traffic and make possible the confinement of extraordinarily heavy traffic to a few roads and thus render unnecessary the building of many to withstand the heaviest traffic. It does not seem wise to limit the weight of loads. We need the most economical transportation that it is possible for transportation experts to devise, but there should be such a regulation of traffic that the heaviest loads shall be carried upon roadways designed to carry them. With a knowledge of traffic requirements, a road system may be laid out for the district under consideration, and it will consist of one or more trunk lines from which lead laterals; and leading from trunks and laterals there must be local highways. Whether it is proposed to lay out an entirely new system or adapt an existing system, the procedure must be approximately the same. Certain roads should be designated as, say, Class A, and on them the heaviest traffic be permitted; others should be designated as Class B, and on them traffic be permitted up to a certain maximum weight of load; on Class C roads the maximum should be still lower. A careful study should be made of routing possibilities in order to reduce to a minimum the Class A roads. It may be that this study in a section already settled will develop the necessity for new roads or for new locations for old roads. It may also show that gradients should be reduced. Proper advancement towards prosperity necessitates a road system over which traffic may move efficiently. This means that, especially on the Class A roads, very easy grades must prevail, sharp curves must be eliminated and all obstructions to clear vision removed at points where such obstructions introduce danger. "Safety First" should be a watchword on the highway as well as on the railway. The advantage of traffic routing will be much greater in

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Mr. Allen. a fairly thickly settled section than in one more sparsely settled, but it will usually be found that the principle involved may be made use of in all cases. After construction, the traffic census should be continued as a guide for future readjustments and to ascertain the effect of traffic upon the different types of pavement used and to determine maintenance requirements. Record of traffic should of course be supplemented by a record of wear.

The selection of road types, even with the digested data of a complete traffic census available, is difficult. Unfortunately, there has been but little investigating to determine the life of a given type in terms of traffic. It is doubtful if it has been done in a systematic manner in any place, and where it has been done at all, the data obtained are not such as to inspire confidence. It may be said that there are several types which have not been used long enough to determine the life, but so far as is known, no one can show data to prove what the wear has been even during the short life that they have had, or the traffic that produced the wear. Where statements have been made giving the life of the older types, the data upon which the statements are made are not given nor is there a description of how the road was built, of what materials, or whether repair work has been done. Until we put into effect a procedure somewhat along the lines above outlined, we shall not begin to make cumulative progress in highway engineering.

For efficient construction of highways we must have well-considered system and organization. Rule-of-thumb methods are firmly entrenched but he believed the time will soon come when more business-like methods will prevail. Whether we are to build a granite block pavement founded on concrete, or a plain earth road, the first requirement should be a definite program of procedure. Such a program should provide not only for a definite progress of work, but for coördination of all its parts; for example, if the contractor crushes his own stone, and he happens to be laying a first course of broken stone, all parts of the work should be timed to keep the stone-crusher constantly at work. Quarrying and transportation to crusher should be conducted so as to furnish at all times just enough rough stone to the crusher and at the same time to keep the quarry force constantly at work. Hauling from the crusher should be at the same rate as the crushing is done, and on the road there should be just sufficient organization constantly at work as is needed to care for the stone being delivered.

From the date a job is begun there should be accurate and detailed cost-accounting with daily reports showing cost of work and amount accomplished. Daily cost-keeping will enable the constructor to keep in close touch with the financial condition of each part of the work and enable him to locate waste or losses and at once apply remedies.

A program which, if followed, will insure an efficient conduct of the work is just as necessary when doing maintenance work.

Paper No. 63

RURAL HIGHWAYS.

Methods of Construction and Maintenance with Special Reference to the Requirements Due to the Introduction of the Automobile.

By

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England

"The road is so necessary an instrument of social well-being that in every new colony it is one of the first things thought of".—*Smiles' "Life of the Engineers"*, Vol. 1.

"There are many standards by which the progress of civilization can be judged. . . . But there is no better criterion of a nation's progress, its organization and efficiency, its commercial and social life, than the quality of the roads it possesses".—*Lord Montague, of Beaulieu.*

One of the difficulties which beset the path of any writer on a subject such as the one under review, when the results of his efforts are to be submitted to an international audience, is that of nomenclature: how best to express in understandable language what he wishes to convey. Another difficulty is, that, however experienced, well-read and travelled he may be, he cannot hope to be on speaking terms with all that is useful and necessary to be known concerning the practice connected with his subject all over the world, but must, almost inevitably, take refuge behind his somewhat insular knowledge of practice and performance as it obtains in the country of his birth or adoption; and in dealing with a topic such as the construction and maintenance of roads, this is peculiarly the case. It, therefore, almost necessarily follows that this paper, however "Interna-

tional'' the Author may try to make and keep it, will more or less reflect English practice in present-day road construction and maintenance.

It is not the Author's intention to attempt to argue what is or ought to be understood by the term ''Rural'' as applied to highways. The word has, in general, the same meaning all over the world, with a more or less extended application. In this country there are rural ''Main'' roads and rural ''District'' roads, the status of each depending on the fact as to whether they are maintained by County or Rural Highway authorities.

But whatever the term may mean in its application to road work, it is certain that the term ''Rural Highways'' comprises almost every type of road, with the probable exception of granite-pitched, wood-paved or sheet asphalt roads, and even these classes of roads are to be found in rural districts near London and other of the more important English cities.

It will thus be realized that the title of the paper is fairly comprehensive.

It is common ground that until the advent of the automobile, in its varying forms and adaptations, by far the greater area of rural highways was constructed and maintained under the water-bound system; the only variant being the character of the aggregate used, and this, of course, depended very largely on the traffic intensity, as well as upon availability of material and, therefore, upon initial cost.

The lack of proper or adequate foundation structure, which is one of the outstanding features of most rural highways, presents an important initial difficulty, and one which (in view of the increased traffic strain to which all roads are now subjected, by reason of the rapid and increasing growth of mechanically propelled traffic) will become, from year to year, more important, and, at the same time, less easy of solution.

It is almost a stock phrase that one cannot be expected to satisfactorily maintain a road unless such road has a good foundation; yet practical road engineers have to get along as best they can, in this connection, by maintaining, year after year, in good condition roads, the chief characteristic of which is the lack of the very foundation which is said to be indispensable to their satisfactory maintenance.

The practical road engineer realizes that it is economically impossible to re-found even a small proportion of the badly founded roads which already exist, and that he must take them for what they are and make the best of them. It is in this connection that there exists a large field for the exercise of the ingenuity of the highwayman in producing on and in connection with the surface of an existing road an element of strength which shall, in some measure at all events, take the place of the foundation which ought to be there, but which never was there.

The necessity for a thorough remodelling of method in road repair and maintenance, which may be said to be the outcome of the revolution in use to which roads are being subjected, has given birth to many ideas, and resuscitation to others; but the consensus of practical opinion appears to point to bituminous products of various kinds as forming a range of available material readily applicable as a binder or flux for use in conjunction with ordinary road stone as the aggregate.

There can be little doubt that a properly prepared tar or bituminised macadam forms one of the best, most practical, and ultimately economical preparations for road surfacing work. One of the difficulties, however, attending the use of this material is, that if the tar compound with which the aggregate is coated is sufficiently distilled and dehydrated, and otherwise properly prepared for road work, the mixing thereof with the stone aggregate must be carried out at the time it is required for use, and, preferably, *in situ.* This is due to the fact that a properly prepared tar compound, especially if in its composition material of an asphaltic nature is introduced, sets off quickly, and possessing as it does only one setting moment, it is incapable of being kept or stored for an appreciable period after incorporation with the stone aggregate, and must be applied to the road soon after its manufacture.

But while the Author is satisfied that bituminous-bound roads are superior in every respect to those constructed under the water-bound system, he is also satisfied that economy—not only initial, but ultimate—could and would be effected by a more modest use of materials. It seems such a waste of good material and labour to re-surface a road to a depth of five or

six inches ($12\frac{1}{2}$ to 15 cm.), when an equally good result could be obtained by the application of a surface coat of $2\frac{1}{2}$ inches ($6\frac{1}{4}$ cm.) thickness. It does not appear to be sufficiently realized by road engineers that (assuming a reasonably good foundation exists, thus providing for the dead-weight resistance of the traffic to which the road is subjected), the wearing surface need not be of great thickness, and indeed may be relatively thin, always assuming that it is composed of properly selected and prepared materials, suitably and intelligently applied.

It has been said that one of the functions of a civil engineer is that of being able to do for a penny what any fool could do for twopence; and if this comparative statement could be said to apply to the civil engineer in general, it certainly has a special application to the work of the road engineer, since it is so very easy to throw away good money on poor materials and unskillful work in the practice of road maintenance.

The advent of the automobile has undoubtedly brought the road question, in all its bearings, into prominence, and has rendered the question of the construction, re-construction, administration and maintenance of highways one of extreme importance in the economy of modern-day life; and it behooves all those engaged in the management of public highways to bring to bear on the subject all the powers of skill and sound judgment of which they are possessed. There is still a great field for the exercise of skill and ingenuity, as well as of high administrative talent, on the part of those engaged in the practice of highway engineering.

Road engineers have had, in the past few years, enormous difficulties to contend with. The great expansion of road traffic has not been accompanied by a correspondingly great expansion of financial means whereby roads could be prepared and fitted to bear such increased and increasing traffic, and the wonder is, not that so little has been done to meet the exigencies of the case, but that so much has been accomplished under circumstances of such difficulty.

The original idea of a paving material for roadways was one forming a hard, rigid wearing surface, the foundation

under it being often considered as a secondary matter. Experience has, however, now demonstrated that, for heavy traffic, a tough and slightly resilient surface material on an unyielding foundation is essential.

Of course the above can only be regarded as a general principle, and must be considered in conjunction with other requisite qualities, such as impermeability, ease in cleansing and repairing, initial cost, etc., as well as local climatic conditions.

The following table (taken from the 1908-9 edition of "Municipal Engineers' Specification", publishing office, Great New Street, London), of the comparative merits of the principal road-paving materials (asphalt, stone setts and wood), shows eighteen qualities which a paving material may possess, and the relative positions of the four materials in regard to those qualities.

Comparative Merits of the Four Principal Road-paving Materials.

Quality.	1st Place.	2nd Place.	3rd Place.	4th Place.
1. Durability as a good, smooth pavement.	Asphalt.	Soft wood.	Hard wood.	Stone setts.
2. Absolute life before wearing through.	Stone setts.	Asphalt.	Hard wood.	Soft wood.
3. Foothold for horses.	Soft wood.	Hard wood.	Stone setts.	Asphalt.
4. Ease of traction.	Asphalt.	Soft wood.	Hard wood.	Stone setts.
5. Economy in first cost, considering durability.	Asphalt.	Stone setts.	Hard wood.	Soft wood.
6. Economy in maintenance.	Asphalt.	Stone setts.	Hard wood.	Soft wood.
7. Ease in repairing.	Asphalt.	Stone setts.	Hard wood. Soft wood.	————
8. Facility for being cleaned.	Asphalt.	Soft wood.	Hard wood.	Stone setts.
9. Elimination of vibration.	Asphalt.	Soft wood.	Hard wood.	Stone setts.
10. Appearance (greatly a matter of opinion).	Asphalt.	Soft wood.	Hard wood.	Stone setts.
11. Sanitary qualifications.	Asphalt.	Stone setts.	Hard wood.	Soft wood.
12. Absence of dust and mud.	Asphalt.	Stone setts.	Hard wood.	Soft wood.
13. Least harmful to nervous system.	Soft wood.	Asphalt.	Hard wood.	Stone setts.
14. Least noise.	Soft wood.	Asphalt.	Hard wood.	Stone setts.
15. For motor traffic.	Asphalt.	Soft wood.	Hard wood.	Stone setts.
16. For heavy, continuous traffic.	Asphalt.	Soft wood.	Hard wood.	Stone setts.
17. For heavy, intermittent traffic.	Stone setts.	Hard wood.	Asphalt.	Soft wood.
18. For light, continuous traffic.	Hard wood.	Soft wood.	Stone setts.	Stone setts.

In the selection of a road-paving material, it often happens that considerations of first cost are permitted to have a greater weight than those of the suitability of the material for its intended purpose.

The terms of years allowed by the Local Government Board of England for the repayment of loans made to municipal authorities for paving roadways are as follows:

Granite setts	20 years.
Rock asphalt	10 "
Hard woods	10 "
Soft woods	5 "

The factors determining the life of a road-paving material are many and varied, such as the character, weight and amount of traffic, the gradients of the road, the character of the foundation, the time of year and manner in which it was laid, the varying quantities of materials employed, climatic conditions, and the liability of the road to disturbance in order to lay or repair mains and services, etc.

In considering the character of materials to be selected for road construction, it would appear that the safety of the resultant road should be the first consideration, after which consideration of cost may be permitted to find a place. It is to be feared that in far too many instances the question of the safety of the traveling public is thought of far too little by those who have the selection of materials. Thus we find, in many cases, hard, brittle, non-absorbent furnace slag coated with tar, which wears to the smoothness of glass and is cruelly dangerous in damp weather, owing to the fact that the material formed by the wear of the road is in the form of a fine powder, which, when wet, forms a slimy, slippery mess upon which it is next to impossible for animals to retain a foothold, and which, on the recurrence of the slightest frost, presents a surface positively inimical to life and limb.

In the United Kingdom, roadmaking with broken stone will always be identified with James Loudoun Macadam, from whom this form of road construction received its name in England. The honour is somewhat unmerited, as the main principles of Macadam's construction are now largely discounte-

nanced, and the methods of his contemporary, Thomas Telford, "the father of English roadmaking", are more generally followed. The differences between the methods of Telford and Macadam may, however, be briefly summarised as follows:

Macadam.

Foundation.—None.

Metalling.—Uniform coat, 11″ thick, of stone broken to a 2″ gauge.

Binding.—None.

Drainage.—Through cross drains, side channels and ditches. Made his roads above level of surrounding country whenever possible.

Telford.

Foundation.—Hand-pitched rock, 7″ deep; tops not to exceed 3″ in width. Interstices filled and consolidated with small stones and levelled off to a cross contour of 1 in 60.

Metalling.—One coat, 7″ deep, of broken stone; no stone exceeding 6 oz. in weight, and all passing through a 2½″ ring.

Binding.—1″ of gravel.

Drainage.—9 stone cross drains to each mile length, delivering into side ditches; channels delivering into cross drain on each side.

The fame of Macadam and Telford as roadmakers was not due so much to original ideas on their part as to their adaptation of existing methods, combined with great administrative capacity. Thus the broken-stone method was already in vogue on the Continent and had been adopted by John Metcalfe, a predecessor of both Macadam and Telford. Trésaguet, the French engineer, was laying roads with hand-pitched rock some 30 years before Telford adopted the method, and it is curious to note that the engineers of the Ponts et Chausées abandoned their own excellent idea for a while, to take up the less sound one of Macadam.

Macadam's theory that the elasticity afforded by the natural road bed was of advantage in giving the property of resiliency to the road bed, and that, therefore, no distinct or separate foundation was required, does not now seem to be accepted; while Telford's elaborate and expensive hand-pitched foundation is only followed, if at all, in road building for heavy traffic, or for the purpose of ensuring adequate under-drainage on clay or other heavy soils.

For the most part, where foundations are put in they consist of a hard core, such as broken bricks, clinker, pottery re-

fuse, etc., rolled, preferably in layers, to the required thickness and formation. The cross-sectional contour of the road surface should be reproduced in the foundation, care being taken to ensure that the shoulders of the road (in the absence of stone or other kerbs and channels) are built up of large material, so as to form buttresses calculated to resist the lateral spread of the road material.

Steam rolling has now become an integral part of the operation of both the construction and maintenance of roads, and few roads are now re-surfaced or extensively repaired without its aid. The advantages to be derived from the use of steam rollers may be said to include: (a) a saving of metalling as well as time, inasmuch as a thinner coat of metalling (being more effectively consolidated) will suffice than would be necessary if consolidation were effected by the traffic; (b) a smoother surface, affording easier traction, can be obtained; (c) the saving of material over the old method of traffic consolidation, as well as the avoidance of damage to vehicles; and (d) economy in binding materials.

A disadvantage of steam rolling is, that very often a much too heavy roller is used, and rolling is carried beyond the effective point, resulting in loss of material by crushing action. Contrary to opinions often expressed, to the effect that the crushing of road stone indicates that the stone itself is of poor quality, the Author has found it possible to considerably damage the best and toughest basalt or porphyritic granite by rolling quite dry with even a six-ton roller; and he considers that an eight-ton roller is quite heavy enough for any but heavy, town work, and that the use of a roller heavier than ten tons does more harm than good on almost any class of work.

The question of the position and depth of sewers, drains, or gas and water pipes also has an important bearing on the question of the use of steam rollers, inasmuch as many hundreds of miles of these pipes were laid at an insufficient depth years before rollers were in common use; and although it is comparatively easy to require that all new pipes be laid so as to have at least 3 feet of cover, the road engineer is, in numerous instances, still confronted with the difficulty of rolling over pipes which are laid at a less depth than 3 feet.

The number of times a roller must pass over a given point to secure effective consolidation varies (1) in proportion to the hardness of the stone; (2) according to the thickness of the layer, but not in proportion to it; and (3) according to the stone, whether wet or dry.

Mr. Rockwell estimates that with a layer 3″ thick a 10- or 12-ton roller must pass over:

Limestone	50 times.
Granite	50 to 75 times.
Porphyry	90 to 100 times.

Watering should be resorted to in the early stages of consolidation, and is best applied by means of a spraying apparatus attached to the roller (so as to spray water on the wheels), which, besides economising the use of water, renders it possible to apply the required quantity, and no more, in an effective and perfectly controlled manner.

On no account should a binder of mud or old road scrapings be used to complete consolidation of the road crust by filling the voids. If a bituminous binder is out of the question (the initial cost of such a binder is its only drawback, as its use is undeniably an ultimate economy), loamy sand, used either alone or in conjunction with granite dust or chippings, is the best binder. All binding agents should be used in correct relative quantities to the weight of stone to be consolidated; the quantity of binder being about one-fourth of the weight of the aggregate, or less, if possible.

Mr. G. Tillson (U. S. A.) advocates fine limestone screenings, and considers trap-rock screenings and sand, in the proportion of three of screenings to two of sand, as giving good results. Trap- and other igneous-rock screenings have little cementation value, and if the binder is solely composed of these, it will require a considerable amount of rolling.

Mr. Deacon, formerly City Engineer, Liverpool, carried out some experiments bearing on this matter, the result of which is stated as follows: Under a 15-ton steam roller, preceded by a watering cart, 1200 sq. yds. of trap-rock macadam, without binding, was only moderately consolidated by 27 hours' continuous rolling. If trap-rock chippings are used, the same area may be moderately consolidated in 18 hours. If siliceous

gravel, from ¾″ to the size of a pin's head, mixed with one-fourth part of macadam sweepings obtained in wet weather be used, the area may be thoroughly consolidated in 9 hours. Macadam laid by the last method wears better than that laid by the second, and that laid by the second much better than that laid by the first.

Experiments conducted by Mr. W. H. Grant, Superintending Engineer of the New York Central Park, in the construction of his park roads demonstrates the necessity of using binding material.

Mr. Grant, in these experiments, followed Macadam's "no-binding" theory. The bottom layer of stone was, under a 12-ton steam roller, sufficiently consolidated to form and retain (after the compression had reached its practical limit) an even and regular surface; but it was found impracticable to solidify the top layer and reduce it to such a surface as would prevent the stones from loosening and being displaced by the action of wheels and horses' feet. No amount of rolling was sufficient to effectually bind the metal, although the rolling was persisted in until the metal was damaged by the extensive crushing action of the roller.

It is generally agreed that any description of binder which is used in conjunction with water should be used sparingly, with a view to filling the voids only, as an excessive quantity of binding material will have the effect of keeping the units of stone apart, will be washed out in wet weather or exuded as the result of traffic pressure in damp weather, thus causing the road crust to lose its even surface.

The question of the scarifying of existing road surfaces previous to partial or entire re-surfacing is one concerning which road engineers entertain somewhat divergent views, but it may be stated as a general proposition that scarifying is only justifiable when the existing road surface or crust consists of sufficient thickness of one grade of material to ensure that the foundation of the road shall not be disturbed by the operation. In such cases, the surface may be safely scarified and cleaned by screening out the binder and small aggregate, adding such a quantity of new material as will bring the road up to the required strength when re-rolled. But if the structure of the

road is at all weak, a new coating of material should be superimposed on the whole work, and the edges and ends only should be picked up or scarified, to ensure a satisfactory join between old and new work.

If scarifying is necessary, it will be better and more economically done by machine than hand, always assuming that the extent of the work to be so carried out justifies the employment of a machine scarifier. In works of small character, hand picking or scarifying may be judged to be more economical.

Concerning the important detail of road maintenance, which is comprehended under the general term "repairs", much may be written. When dealing with "water-bound" roads the method of repair adopted appears to be very largely governed by the personal predilections of individual surveyors, one section of whom rely principally on what may be termed the continual-patching method, while others prefer the complete re-coating method. Possibly a system which includes both methods is the more to be preferred. On the one hand, the patching method requires a fair amount of skill for its proper performance and, if carefully and consistently carried out, will render a road more comfortable for traffic, but it will not entirely eliminate the necessity for occasional re-coating, inasmuch as it is next to impossible to restore, by this method, the exact amount of wear to which any given road is subjected. On the other hand, it often becomes necessary, even when a road has been re-surfaced, to undertake repairs to weak places or pot-holes which may shew themselves from time to time.

It has often been a subject of conjecture as to why a recently re-surfaced road should develop pot-holes on its upper surface, when the whole of the re-surfacing material is, theoretically at all events, of similar texture or hardness; and the Author has arrived at the conclusion that this may be due to the fact that, where pot-holes occur, the granite or other material has been originally spread rather more thickly than on the general body of the work, and in the subsequent steam rolling the material on these high places has been more damaged or weakened by crushing under the influence of the roll-

ing, thus rendering the road weaker at the very points where, in the first instance, a slight excess of material had been inadvertently or unskillfully applied.

The principal defects connected with the repair of road surfaces may be said to be:

(1) Unskillful application of materials.
(2) Application of unsuitable materials.
(3) Inadequate amount of materials employed, resulting in the "starving" of the road.
(4) Insufficient supply of labour and consequent neglect.
(5) The employment of unskilled labour.
(6) Neglect of proper consolidation of materials, even in small patching work.

It is as possible to over-metal a road as it is to jeopardize its condition by a too sparing use of material; a surface over-coated will be less likely to be strong and homogeneous in structure than one to which has been applied a sufficient but not too generous a coating. It should never be forgotten that the principal strain to which the average road is subjected is that of the frictional and attritional wear on its surface, and, therefore, if a just sufficient thickness of resistant material is applied to the surface, the under coating, or sub-structure, may be quite properly formed of a softer or cheaper material, as it has only a dead-weight load to sustain and transmit to the earth foundation, and is not subjected to the other influences above mentioned.

The suitability or adequacy of foundation and the character of the sub-drainage of a road are other important elements which cannot be overlooked or neglected in considering the question of road maintenance or administration, as it would be of little use to look for successful results, with whatever skill or care a road had been repaired, if its foundation or drainage was either insufficient or unsuited to its purpose; and no hard and fast rules can be laid down in this connection which would be appropriate to all circumstances. With respect to the general question of foundations to ordinary country roads, it often happens that one is not bound to observe such fixed surface levels as would be necessary in towns or places where kerbs

and channels are already laid. It will, therefore, often be found sufficient, in order to strengthen a weakly founded road, to leave what foundations may already exist and apply a coating over the same of a thickness sufficient to render the road strong enough for the work it is called on to do.

The Author has also, on many occasions, strengthened a weak road (especially on clay subsoil) by strengthening or buttressing the shoulders. This is done by excavating trenches of, say, 1′ to 6″ wide and deep on each side of the road next the edge, or verges, and filling these trenches to the surface of the road with gravel or chalk flints of 4″ to 3″ gauge, well rolled down. These side buttresses not only serve to drain the soil under the road (outlets at intervals and in low places being provided) but are of considerable assistance in counteracting the lateral "spread" of the subsoil, which is very often the cause of collapse of the road surface.

For the better protection of the surfaces of roads constructed under the water-bound system, the application of a surface coating of distilled and dehydrated tar will be found to be ultimately economical, especially if a dressing of fine granite chippings is spread over the surface immediately after the application of the tar preparation and rolled in; but before this surface coating is applied, the road should be brought up to a proper surface contour. This treatment, however, can only be said to have a relatively temporary effect, and it will be found to be more economical, so far as the ultimate result is concerned, to incorporate the tar compound in the structure of the road surface once and for all, than to repeatedly apply it to the road surface.

DISCUSSION

Mr. T. Warren Allen,* M. Am. Soc. C. E. (by letter), called attention to the fact that there are several types of rural highway construction in use, and of necessity the construction and maintenance methods for each are somewhat different. Mr. Allen.

Whatever the type of road selected, there must be prepared for it a proper foundation, and this foundation must be well drained and thoroughly consolidated. In the United States insufficient attention is given to the subjects of foundation drainage and consolidation, and such attention is especially necessary when there is to be an expensive super-

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Mr. Allen. structure. The practice in many cases where wet ground is encountered is to cover it with a layer of rather large sized stones instead of putting in drains. The value of foundation drains in the early spring, when they operate to prevent saturation of the soil, cannot be overestimated. It is the exception rather than the rule that the foundation is properly rolled before putting down the paving. It is usual, in order to obtain the best results, to use a heavy roller—from ten to fifteen tons—and to roll while the soil is damp until thorough consolidation is obtained. Where there are embankments of such a depth that settlement is liable to occur, even though extreme care is taken during the making of the fills, the best practice is to defer putting down the surfacing until the following season.

For practically all road types, the first course placed upon the foundation is usually a layer of broken stone or one of concrete. The best practice in the United States provides, when this course is of broken stone, that it shall be filled with stone screenings or sand and thoroughly consolidated. The stone is rolled previous to filling until it is firm and unyielding, and then the filling material is added dry, swept in, and the course re-rolled. When no more filling material will go in dry, the road is sprinkled and rolled and filling added until no more may be gotten in in this manner. The first course will fill itself under traffic either from the bottom or the top, or both, if not filled during construction, and the stability of the road is thereby impaired. If the first course is of concrete, it must, of course, be thoroughly consolidated, and before the concrete has begun to set. Attempted consolidation during the process of setting has done damage and, in some cases, later disintegration was undoubtedly so caused. The writer agreed with Mr. Gladwell that the cross-sectional contour of the road should be reproduced in finishing the lower courses. Unless this is done the result is often a road with an uneven or bumpy surface or one which will later develop such a surface.

Mr. Gladwell refers to crushing of stone by excessive rolling. The writer believes this is more likely to injure the top than the bottom course. It has occurred to the writer that a stone test might be devised which would indicate the amount of rolling which different qualities of stone may safely be subjected to.

One of the types of roads widely used in the United States to withstand motor-car traffic is the bituminous macadam—a road constructed about as the water-bound macadam, but before the introduction of the filling of screenings in the top course, bituminous material is poured in to cement and hold in place the road stone as previously consolidated. The top course is first thoroughly consolidated and then this consolidated condition is preserved by heavy bituminous material poured in while heated to a temperature of about 380° F. The road surface must be sufficiently open to permit a uniform introduction of the bitumen. After the pouring, stone screenings are rolled in to further fill the voids, after

which the road is sealed with a light and uniform covering of bituminous material, on the top of which is spread stone screenings. The top course of a road should be so compacted during construction that it will not be further compacted later under traffic. Insufficient consolidation is one of the frequent reasons for ruts. The bottom course of the bituminous-macadam type is usually five inches thick and the top course three inches, with 1½ gallons per square yard used in the first pouring and ⅜ gallon per square yard for the seal coat. Mr. Allen.

Successful road construction requires extreme care. The adoption of no one type will preclude it. There is no magic whereby any one type becomes automatically fool-proof. In each case that type of road should be selected which will efficiently bear the traffic which is to come upon it, but unfortunately in most parts of the United States it is usually necessary to select the type which will come the nearest to standing up without maintenance.

It is possible to construct highways which, with proper maintenance, will stand up under all kinds of motor-vehicle traffic, but there is a large mileage in the United States which was constructed before the automobile made its appearance or before its effect was appreciated.

Present-day practice in the United States favors the gang system of intermittent maintenance for the higher types of road surfaces and the patrol system of continuous maintenance for the remainder. The object of maintenance is to preserve a road in the condition in which it is immediately after completion of construction. Improvement, repair and maintenance are used interchangeably. When a road has been constructed with a durable surface, subsequent work upon it is usually classed as maintenance. To withstand motor-vehicle traffic, a water-bound road, if in good condition, is usually improved, after being thoroughly cleaned, by a uniform surface treatment of heavy bituminous material applied hot at the rate of about ⅜ gallon per square yard and covered with stone screenings, after which it is ready for maintenance.

Maintenance of all types of roads must result in clean road shoulders, ditches and culverts. Maintenance of the bituminous-covered water-bound macadam requires, in addition, that the road surface be kept in a uniform condition by patching when necessary, until the covering is worn out generally, when the road must be repaired by again covering with bituminous material and stone screening. This covering of a water-bound macadam road waterproofs it and it ceases to be water-bound; therefore, it must be kept covered or pot-holes will develop.

The maintenance of the bituminous-macadam should be by the gang system and intermittent. About every fourth or fifth year it will be necessary to renew the seal coat.

Mr. L. W. Page,† M. Am. Soc. C. E. (by letter), desired to comment on the author's remarks regarding the effect of unsound foundations on the wearing course of the road. Mr. Page.

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Mr. Page. While he thoroughly agreed with Mr. Gladwell that an adequate foundation is the first essential of a road structure, he desired to call attention to the fact that in certain cases the foundation of a road is frequently considered the cause of an unsatisfactory wearing course when the fault itself is really in the method of constructing the wearing course. He referred particularly to bituminous macadam roads constructed by the penetration method.

In the construction of such roads, many engineers believe that securing a penetration of the bituminous materials for a depth of two or three inches is the most important thing to consider. While it is true that uniform penetration is highly desirable for practically the entire depth of the wearing course, the method of attempting to obtain it frequently results in a road surface which is far from satisfactory, either from the standpoint of the road user or of the engineer who is obliged to maintain the surface.

One of the fundamental principles to be observed in any type of broken-stone road construction is to secure an interlocking of the broken-stone fragments in order to obtain mechanical stability. Unless the larger fragments of broken stone key together, the wearing course is sure to be displaced to a certain extent under traffic and ultimately to present a wavy and uneven appearance.

In the construction of bituminous macadam roads according to the penetration method, many engineers feel that satisfactory penetration of the bitumen cannot be secured if the road stone is first compacted and keyed together by rolling, and as a result it has been a not uncommon practice to require that the wearing course of broken stone be merely shaped before the first application of bituminous material is made. While greater penetration of the bituminous material may perhaps be secured by this means, it is practically impossible, after the bitumen has once been applied, to interlock the broken stone to the same extent as before applying the bituminous material. This is true no matter how much the road may be rolled after the bituminous material is applied.

He believed that lack of rolling during the initial stages of construction is undoubtedly responsible for the wavy condition of many bituminous macadam roads, which condition is frequently attributed to poor foundation. After application, a rapid cooling of the bituminous material takes place and a false set of the wearing course of stone occurs, unless it has been previously keyed together by thorough rolling. It is very difficult to completely break down this false set by ordinary rolling, and if the set is once broken it is seldom that the stone will key together, because of the thickness of the coating of bituminous material upon the stone fragments, which tend to slide about rather than to interlock under the roller.

He considered that it is of the utmost importance to consolidate the stone before applying the bituminous material, and believed that if this principle is observed, many cases of unsatisfactory condition or failure of the wearing course, which are attributed to faulty foundation, will be prevented.

Paper No. 64

"SOLIDITIT" CONCRETE ROADS IN ITALY.

Notes by

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THE IDEAL ROAD PAVING.

The ideal paving for roads of great traffic is an immense continuous slab of granite or porphyry, of fine grain, with a smooth and impermeable surface, but not slippery; hard and homogeneous enough to wear slowly and uniformly under the weight of the traffic and the blows from the horses' hoofs; and of such composition that could be easily renewed by filling up the worn parts with new material that would adhere perfectly to the old. This pavement, besides causing neither dust nor dirt, should be almost noiseless, have a pleasant appearance and be of small cost. To this ideal,—truly difficult, if not impossible, to attain,—the nearest approach is a pavement made of a very fine-grained agglomerate laid on a hard base, such as asphalt concrete resting on a cement-concrete bed, or, better still, a very hard cement concrete, laid on a stratum of gravel heavily rolled.

Both these types of roads are in use in America and have been recently adopted in Europe. The latter type, with a special cement surface, is coming into use in Italy, where the road pavings of asphalt or wood are too costly.

PAVINGS OF ASPHALT AND OF CONCRETE.

The pavings with asphalt or bituminous binder answer to many of the requisites above specified, but they have the inconvenience of being slippery in wet weather, softening in summer, and have a tendency to crack in winter.

They have a somewhat sombre appearance and produce a certain amount of dust of dark colour, rather sticky and with a slight odour (which is unpleasant to some) but, above all, are too expensive. However, up to the present, they constitute the most perfect road paving; and, in fact, we meet them in the largest and wealthiest cities, where the traffic is not too great, and where a smooth surface, regardless of cost, is required for mechanical traction.

The other paving is the outcome of several years of study and experimenting to find an agglomerate in which the components could be united by reciprocal, chemical action, and not, as generally happens, by simple mechanical adhesion of the cement paste with the sand and gravel. Some years ago this special concrete was obtained, by the Portland Casalesi Co., of Genoa, by the adoption of a new kind of cement, called "Soliditit", with a high percentage of silica—nearly treble that of the ordinary Portland cement.(1) Thus the tensile and crushing tests give much higher results than the best concrete formed by the usual Portland cement.

Of the hardness and resistance to wear of this concrete—which might truly be compared to an artificial granite—one can form an idea from the following tests made by Prof. Guidi in his laboratory of the Royal University of Turin.

Compression Tests of the Artificial Stone made with Crushed Granite and "Soliditit" Cement.

Test	Dimensions Inches	Surface Sq. in.	Resistance Total	Resistance Lbs. per sq. in.	Observations
1	1.96 x 1.76 x 1.94	3.84	15.30	8,950	Noisy breakage
2	1.96 x 1.95 x 1.96	3.82	21.40	12,500	" "
3	2 x 2 x 1.99	3.99	21.40	12,010	" "

(1)In fact, the proportion of silica to lime in the "Soliditit" cement is as 46.38 of silica soluble to 43.12 of lime, that is to say, 1⅛ to 1; while the proportion of the usual Portland cements is 22 of silica insoluble to 62 of lime, or nearly 1 to 3.

The concrete obtained by mixing this "Soliditit" cement with hard gravel or broken stone, is no longer a simple mixture, resistant by the mechanical adhesion of the cement on the gravel, but becomes a definite chemical compound, in which the excess of soluble silica in the cement reacts on the gravel.

Wearing Test on a Sample of the Same Material Done With Ansler's Machine.

Distance covered = 1640 feet   Total pressure on the sample, 44 lb. 2 oz.
44 lb. 3 oz.

Test	Surface Sq. in.	Pressure Lbs. sq. in.	Height In.	Height In.	Weight Initial Oz.	Weight Final Oz.	Observations
1	1.98 x 1.98 = 3.94	11.2	2	.224	11	9.75	Tests on dry elements
2	1.98 x 1.98 = 3.94	11.2	1.79	.256	9.9	8.35	Tests on wet elements

These tests show a most unusual resistance to compression—up to 12,500 lbs. per sq. inch—almost equal to that of ordinary sandstones and nearly double the resistance of the best concrete, even if made with the finest Portland cement. This new conglomerate derives its resistance, it is well to repeat, not by the simple adhesion of the cement to the gravel, but by a real chemical reaction between this special "Soliditit" cement and the crushed gravel.

The result is really an artificial sandstone or, better still, an artificial granite, and both the laboratory experiments shown above and the actual tests on the main roads of Northern Italy, subjected to heavy traffic, demonstrate that this artificial granite has almost the same wearing properties as the ordinary hard granite used for road pavings in many Italian cities.

PAVEMENTS OF "SOLIDITIT".

This kind of pavement requires a foundation of ordinary macadam, heavily rolled so as to afford a good basis to the wearing surface. This wearing surface is formed by a layer 2 to 3 inches deep at the sides, and from 3 to 3½ inches at the crown, of a mixture of finely crushed gravel and the special "Soliditit" cement, mixed rather dry and heavily tamped in place till the water oozes to the surface. Thus the top layer acts as an immense slab of artificial granite for the whole width and length of the road, there being no joints, which are always a cause of damage.

The result is a surface as smooth as asphalt or wood, but not slippery, and which allows a very good grip for the hoofs of the animals, even in damp weather. It produces scarcely any dust,

neither expands nor shrinks under changes of temperature, causes little wear to the tyres of the vehicles, has a better colour and appearance than that of the asphalt, and is almost like granite in colour.

Finally, in case of wearing or repairing, the cavities or parts perished can be refilled with new agglomerate that binds itself to the old, precisely as happens in the paving with asphalt, and its first cost and annual maintenance are less than those of other high-class pavings. In fact, the cost of this "Soliditit" pavement varies from 8 to 10 shillings ($2.00 to $2.50) per square yard, according to the distance the cement and crushed quartz must be brought, as the cost of the transport has a great influence on the final cost of the work.

APPLICATIONS TO ITALIAN ROADS.

Although concrete roads are becoming quite common in America—the best examples being around Detroit, Washington and Chicago, and a very fine example may be seen in Central Park of New York—still the concrete for these roads, being made with ordinary Portland cement and the elements of the concrete being kept together only by adhesion, their resistance is not very great; under heavy traffic they wear away rather rapidly. Generally they need extensive repairs after 4 to 5 years' use, although the thickness of this concrete is nearly 15 inches. The new concrete, made with "Soliditit" cement and with a thickness of three inches, produces a road surface that after 5 years barely shows any marks of wear and tear. Extensive experiments have been made on the national roads at Alexandria, Torino, Milan, Palermo and Rome, but the most important are around Casale, the principal cement centre of Italy. The Road Engineer of Alexandria, Signor S. Riviera, in an official report of June, 1913, states that on the Casale road, subject to very intense traffic, and where on market days there is a transit of 2500 vehicles in 12 hours, some of fully 150 cwt., the average consumption of the road surface is only 1 to 2 millimetres per year (2/24 to 3/24 of an inch), and in the centre, where the traffic is heaviest, it does not exceed 3 m.m. (or ⅛ of an inch) per year.

After 5 years of service the road does not show any unevenness of surface, neither ruts, cracks, nor abnormal marks of deterioration under the influence of traffic and variations of temperature, from heavy frost in winter, to very great heat in summer. The surface is quite even, and the granules of granite wearing away a little more quickly than the surrounding mass of "Soliditit" cement, is not slippery even during heavy frosts.

The Chief Road-Engineer of Milan, Signor J. Vandone, President of the Italian Society of Municipal Engineers, in an address to the Italian Road Congress(1) says:

"Speaking of roads with rigid surfaces, we must mention the important experiments made on concrete roads surfaced with a special concrete composed of fine pieces of gravel and a special cement called "Soliditit", with a much higher percentage of silica than the usual Portland cement and which is produced by the "Società Portland Casalesi" at their manufactory of Casale Monferrato (Italy).

"This concrete offers such resistance under heavy and rapid traffic that its wear is comparable to that of the granite of which it is composed. An experiment made on the "Milano-Monza" road shows that after 6000 passages of the "normal wheel"(2) —corresponding to the annual traffic of an ordinary highway— the mean depth of the rut was 1½ millimetres, and under 16,000 passages, which might be given as an example of the heaviest traffic in Italy, it was only 3¾ m.m. (⅛ of an inch).

"The experiments of traction made with a dynamometer show an average co-efficient of traction of 1/60 of the load, which compares very favourably with the co-efficient of traction on a good paved road.

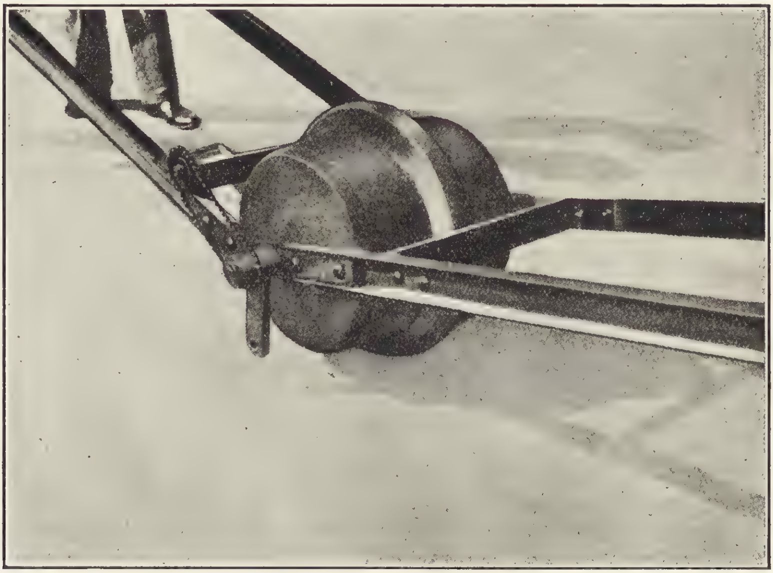
(1) Normal methods for testing road materials, Atti del Collegio degli Ingegneri di Milano, 1914.

(2) The "normal wheel" for experimental purposes has a diameter of 20 inches (metres 0.50), a width of tyre of 1¾ inches (4 centimetres), and weighs 8 cwt. (400 kilograms), that is, 2 cwt. (100 kilograms) for each centimetre of tyre. This is in accordance with the regulations of the International Road Congress of Bruxelles which gave the formula,

$$P = \text{kg. } 150 \sqrt{D}$$

that is, the weight P on the tyre expressed in kilograms is equal to 150 kilograms multiplied by the square root of the diameter D of the wheel expressed in metres.

"Experiments made in order to ascertain the "grip" of the horses' hoofs on the pavement show that the effort made by a horse weighing 10 cwt. (500 kg.) in starting a cart weighing 75 cwt. (3700 kg.) was 8 cwt. (400 kg.), without any sign of slipping, so that the animal had a normal grip on the "Soliditit" concrete surface".



The Normal Wheel for Testing the Durability of a Material for Road Surfacing.

CONCLUSION.

The experience gained in Italy on the several concrete roads made with this special "Soliditit" cement, mixed with crushed gravel and a very small percentage of water, but heavily tamped, is most satisfactory. The road surface resists like an immense and jointless slab of granite; it has all the merits of a good asphalt pavement without the defect of being slippery; is quite unaffected by frosts and the great heat of Northern Italy, and above all, wears better and longer and costs less than any other system of road surfacing, such as asphalt, wood or granite, or any other pavement specially adapted for heavy and rapidly moving traffic.

Paper No. 65

THERMAL AND TRAFFIC EFFECTS ON STREET PAVEMENTS.

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The tests on which these remarks are based were made in Cleveland, Ohio, and vicinity in 1911 and subsequent years, and in Kansas City, Mo., in 1913. Those in Cleveland referred to grouted brick in which thermal effects were observed on short reference lengths, established on different parts of the pavements, in both lengthwise and crosswise directions. At Kansas City the tests were made upon the effects of changes in temperature of cement pavements, and on the local depressions of roadways and pavements caused by wheel loads, comprising different types from water-bound macadam to grouted granite blocks. To these observations were added some others on the changes in slope of the surface of an asphalt macadam, the latter a temperature effect.

The results of certain of these observations were presented before the American Society for Municipal Improvements, at its Dallas, Texas, meeting of November 14, 1912, and later additional results were placed before the Ohio Engineering Society, at its thirty-fifth annual meeting, held at Columbus, Ohio, February 11-13, 1914.

Referring to the Cleveland work, a review of the results shows that in a well-laid, cement-grouted, brick pavement thermal changes are among the most destructive influences which are encountered, if indeed they are not chiefly responsible for the loss in integrity witnessed in the development of many of those cracks which are prevalent in this type of pavement. A wide range in temperature must be endured by all exposed materials of con-

struction. Were such variations of temperature absent there is no reasonable doubt that a brick pavement could be laid which would for years endure the abrasion and wear of street traffic unimpaired, successfully meeting the prime purpose for which it was laid.

The construction of a grouted pavement is, however, an engineering matter in which thermal effects must be reckoned with. Apparently, such influences have not been given adequate consideration and efforts have not been made to ameliorate their effects in the energetic manner which their importance demands. Pronounced effects of temperature are seldom absent in grouted brick pavements which have been laid for a term of one or more years, and not infrequently such evidence is presented during their first season in use. Critical examinations have at times revealed the presence of incipient cracks in pavements before the street was open to traffic.

The phases through which grouted brick pavements pass were clearly defined in these observations, and their appearance occurred so punctually that the condition in which parts of the pavement would be found after the lapse of an interval of time could be foretold with certainty. This circumstance does not detract, necessarily, from a proper appreciation of the merits of this type of pavement. On the other hand, it is believed that the failure on the part of paving engineers to fully understand the thermal effects and tendencies has been a deterrent to the more extensive introduction of this valuable paving material. More specific data and full realization of the inherent difficulties of the problem would prevent disappointment when witnessing results which in a measure are not preventable.

A grouted brick pavement not infrequently encounters a critical phase within a few hours after the grout has been applied. The usual drop in temperature at nightfall causes a contraction in the pavement which the fresh grout is not in condition to resist. It is impracticable to cover the pavement with a sufficient layer of sand to serve as a non-conductor and maintain a constant temperature in the brick work until the grout has set and acquired a substantial part of its final strength. Incipient cracks are formed in this manner at this early stage, or planes of weakness in the grout are induced which subsequently develop into

cracks. Contact with the curb stones frequently leads to the formation of cracks in the brick work opposite the end joints of the curb stones, the effects of a drop in temperature concentrating at such places.

The partially set grout, exposed to strains of tension when a drop in temperature takes place, is exposed to compressive stress when a rise in temperature next occurs. Exposure to these alternate stresses during the period of setting is generally detrimental to the final strength of the grout. Provided the brick are laid in contact with each other, their lugs will sustain a portion of the compressive stresses, but no assistance is given the pavement against tensile stresses.

If, perchance, conditions are unusually favorable during the setting of the grout and thermal cracks are not then formed, the variations in temperature, diurnal and seasonal, in the subsequent experience of the pavement will be sufficient to overstrain it and induce cracks to develop. So shallow a depth of surfacing material, and of such great extent, could not be expected exempt from thermal influences.

Pavements, however, are not subjected to the same conditions in all parts of their length, either as to kind or magnitude of internal stresses, still referring to monolithic construction such as a grouted pavement is supposed to be. These varying conditions should be recognized and constructive details modified to meet them whenever it is feasible to do so.

Since the phases through which grouted brick pavements pass were clearly shown in the Cleveland observations, it is not considered necessary to make further observations on the particular gauged lengths which were established in the streets of that city. Some of the reference lengths have already reached such a state of distortion that measurements of precision are no longer practicable. The movements, which still continue, are of such an order that their effects are discernible without the aid of instruments.

The observations which were made on new pavements were confirmed by the data acquired in the examination of those of an earlier period of laying. Thermal cracks were, in general, visible in pavements of different ages, and those of recent construction are undergoing the same cycle of changes which has

been passed through by the older pavements. Present methods of construction do not overcome these common defects. In fact, it is probable that expansive forces which are generated through changes in temperature will be greater in pavements of current laying over those of earlier date by reason of the greater compressive strength and higher moduli of elasticity of the brick of present manufacture. In other respects there appears no material difference between the old and the new, thermal effects being the same in kind in each.

Referring in detail to the phases through which the pavements were followed, an early tendency was noted to open cracks which extended across the width of the street. As pavements are commonly laid, the joints are continuous from curb to curb, hence a crack once started has a favorable opportunity presented it to extend and in length eventually to cover the full width of the roadway. They start as fine lines, but increase in width after repeated changes in temperature, finally attaining a width of several hundredths of an inch.

Traffic in passing over these open cracks causes a shearing movement in the pavement, attended with abrasion of the material, and at periods of lower temperature grit sifts into the cracks. The cracks gradually fill, and due to repeated changes in temperature, compressive stresses of considerable magnitude are generated in the pavement lengthwise the street. The compressive force thus generated is too great to admit of being restrained by independent available means. The only force or resistance which is capable of meeting and overcoming this internal state of compression appears to be furnished by the weight of the pavement itself on a long stretch of tangent.

Marginal curbs at railway crossings and at the open ends of streets are overturned by the forces generated, trolley tracks in streets which cross the ends of grouted pavements are deflected by the pressure from the side streets, pavements of lesser compressive resistance are encroached upon, and intermediate stretches of tar-filled brick pavement are shortened in length. Man-hole frames are tilted and catch-basin gratings are sheared by this onward creeping of grouted brick pavements, the progress of which grades do not arrest.

Pavements tend to remain in good order, after they have

reached a state of internal compression, over portions of their length where sufficient endwise resistance is maintained to compensate for changes in temperature. Such a section of pavement was included in the Cleveland observations, one so situated that practically no change in longitudinal dimensions occurred during the reduction in temperature from summer heat to cool fall weather. At this place the contraction of the pavement due to its drop in temperature was compensated for by relief of internal compression. The situation was one well calculated to maintain a grouted brick pavement intact, clearly indicating the advantages, if certain other conditions are met, of keeping the pavement in a state of internal compression.

Unfavorable conditions are presented at the open ends of streets, and at curves, single and reversed. A more or less shattered state of the pavement is characteristic of such places. Variations in temperature cause these places to be frequently put into a state of tension, but since the tensile strength of the grout is not sufficient to drag any considerable extent of pavement over a sand cushion, or base, tension fractures or cracks necessarily result.

In this analysis of conditions which prevail, it is seen that there are places in which a state of compression is maintained during a considerable portion of the time, departing from which localities the magnitude of the compressive stresses diminishes, thence passing through neutral zones and eventually merging into sections in which tensile strains predominate. The conditions which affect a pavement will, therefore, be judged of according to position. It is not, therefore, a matter of surprise that differences in the structural state of a pavement are witnessed in different parts of its length. Internal strains of tension or compression may exist and each of varying degree of intensity.

Detached sections, with broken bond, do not have the distributive ability of intact pavements or those which are firmly held together by initial compression. Measurements have shown that wheel loads are distributed over wide areas in the case of intact grouted pavements. When relieved from internal compression or when in a state of tension the strength is impaired. Cracks near the open ends of streets may result from inability to meet traffic conditions and thermal effects, singly or combined.

Shearing stresses are set up at curves, the most serious effects being witnessed at short reversed curves. Extensive shattering of the pavement generally occurs at such places. The creep of the pavement, practically unresisted, advances from each tangent. The pavement moves over against the outer curbing with force, leaving an open space next the inner curb. An open space two inches in width between the pavement and the inner curb is not uncommon, with an open joint along the curbing for a distance of one hundred feet or more. It is an urgent matter to introduce some method of laying grouted pavements at curves which will provide for a movement of this kind, which is certain to take place. The use of unbonded slip-joints to relieve shearing stresses suggests itself.

The preceding remarks have had reference to the development of cracks extending crosswise the street. The disfigurement of the street is perhaps greater when longitudinal cracks are formed. Longitudinal cracks may be ascribed to two principal causes, fracture through bending stresses on account of defective support, or by reason of buckling from expansive forces. The transverse bending which a brick will endure without fracture is clearly a very limited amount. As commonly laid the bricks break joints in one direction only, and flexure, which would separate the pavement along the continuous joints crosswise the street, when taken longitudinally causes the rupture of at least alternate courses of brick.

A majority of the longitudinal cracks appear to start at the top surface of the pavement and extend downward through the brick. The elastic supporting power of the sand cushion, base and sub-grade are factors in the development of longitudinal cracks, many of which have their period of formation out of season when frost could enter as a factor. The depression of trolley tracks in contact with grouted pavement is a menace to the integrity of the latter. Few trolley tracks possess sufficient rigidity to justify bonding to them. The formation of longitudinal cracks occurring, as they frequently do, in streets carrying only light traffic precludes explaining their presence as being primarily due to the stresses of wheel loads.

Attention is directed to excessive crowning as a source of trouble in the formation of longitudinal seams. This is one of

the most easily modified details in the laying of a pavement, the correction of which would seem to remove a conspicuous source of trouble, changing the shape from the usual amount of crowning to a flat surface or one of such flatness as merely required to turn the water. Some situations admit of laying the pavement flat, with one edge slightly higher than the other.

Crowned pavements are obviously not well adapted to resist compressive stresses applied in a crosswise direction. Bridge engineers would not permit the use of bent columns, employing compression members initially bent one diameter out of line. Similarly, paving engineers are not justified in specifying a shape which exposes monolithic construction to unfavorable and destructive compressive stresses.

Concerning expansion joints at the curbing, they appear of doubtful utility. In the case of a 25-foot roadway, one eighth of an inch on a side is more clearance than required to take up the expansion due to a range of temperature of 100 degrees F. Apparently the only function which expansion joints at the curbing can perform consists of the prevention of buckling of the pavement when exposed to high temperatures, but in this they do not appear to have been successful. Discontinuing the use of expansion joints at the curbing and reducing the crowning of the roadway it is believed would be attended with favorable results.

It is the aim, in laying block pavements in general, to get the individual blocks firmly wedged together. The Cleveland observations led to the same conclusion in respect to grouted brick that pertains to other classes of pavement. With well filled joints and proper shape to sustain compressive stresses, evenly disposed throughout the depth of the brick, it appears advantageous to maintain the pavement in a state of horizontal compression, both crosswise and lengthwise the street, and to maintain it in this state as much of the time as possible.

The construction of a grouted brick pavement is an engineering problem of great delicacy in its execution. It is evident, judging from the behavior of old and new pavements, that methods of construction outweigh in importance some of the requirements of current specifications under which the brick themselves are accepted. It is the engineering and not the manu-

facturing end to which attention is now most needed, having reference to grouted brick pavements. The engineering requirements in the construction of sand-filled and other types of brick pavements are far less rigorous.

Grouted pavement is the most common type laid in Cleveland and vicinity. Other types have their advocates in different sections of the country, particularly in the Middle West, where there is a disposition to use brick with other fillers. The possible disfigurement of residential streets with longitudinal and crosswise cracks in grouted brick undoubtedly militates against this type of pavement. There are streets in Kansas City paved with sand-filled brick in good condition after having been in use for long periods. The excellent appearance presented by such a street on which the pavement was laid twenty-three years ago illustrates the value of well laid sand-filled pavements.

The physical difficulties which are encountered in the laying of grouted brick pavements are so great that other types may properly be given careful consideration. A sand-filled brick pavement, laid on a suitable base, embodies many features which commend its trial. In this type the brick act more as separate units in their individual capacity. Their distributive ability is less than in monolithic construction, as would be expected.

Kansas City presents many streets on which concrete slabs have been laid, differing in no essential respect from the concrete base of an ordinary brick-paved street. The cost of such a pavement, with the brick omitted, is less, naturally, than one with the brick surface included. A considerable number of residential streets are paved in this manner, and one thoroughfare of prominence which carries heavy traffic. The concrete is laid in large slabs, the full width of the roadway and about 30 feet long each. Joints between the slabs are intended to be contraction joints and are so designated, in contradistinction to expansion joints. It is recognized by the City Engineers that the slabs will resist compressive stresses better than tensile stresses, and the constructive details of the pavements are regulated accordingly. Building paper is used in the contraction joints to separate adjacent slabs.

The concrete pavement of Sixth Street, which is exposed to heavy traffic, has not shown durable qualities. The concrete is

much worn, shows irregular wear with many deep "chug holes", so-called, the abraided material making this street a very dusty one. A weaker material than brick or stone may meet the requirements of light traffic, and its use in such locations be justified. A pavement, as an engineering structure, admits of the proper selection of materials to meet service requirements, as in other engineering examples.

Thermal changes affect concrete slabs, and Kansas City pavements furnish examples of thermal cracks in different stages of development. There are fine lines in the more recently laid pavements, with wide and long cracks in those which have been laid for a number of seasons. They traverse the slabs in a general longitudinal direction.

The introduction of tie-rods embedded in the concrete and extending from curb to curb, to draw the slabs together laterally when a drop in temperature occurs, should be serviceable in preventing the formation of such cracks, or, when formed, retard their rate of development. The width and length of many of these cracks in the Kansas City streets make them conspicuous defects.

Observations were made on a concrete pavement of unusual width and depth of slab. The roadway was 50 feet wide with a thickness of concrete of 8 inches. The locality selected for the observations was in a cut, one embankment of which shaded the roadway on one side of the street, while the other formed an angle exposed to the sun, a situation calculated to introduce wide variations in temperature in the concrete.

A drop in temperature of the surface of the concrete of 34 degrees F. caused a contraction on the solid slab of two thousandths of an inch on a gauged length of 20 inches, while a corresponding observation across a contraction joint showed the opening had increased in width over three hundredths of an inch. The slabs in this street showed incipient cracks at the edges at, or in the vicinity of, the end joints of the curbing, after the manner cracks were formed in grouted brick pavements.

The durability of a monolithic pavement, whether of grouted brick or concrete slabs, in respect to maintaining its integrity, is a test of its ability to endure thermal changes. This is further illustrated in an experimental roadway, now two years old, laid

at Chevy Chase, near Washington, D. C. The traffic on this roadway is quite light, and the concrete sections have not shown material wear. Variations in temperature have, however, caused the development of both transverse and longitudinal cracks, in both the brick and the concrete sections.

There are occasional crosswise cracks in the grouted brick sections of the roadway, and a number of longitudinal cracks, the longest of the latter being about 35 feet. The pavement is laid with very little crowning and has soft-filled expansion joints at the curbing. The concrete slabs forming other sections of this experimental roadway display both transverse and longitudinal cracks, the longest of the latter being about 135 feet long. The open cracks in the concrete have been patched with a soft tar filler to aid in the preservation of the slabs.

These slabs display the same traits which were noticed in the Kansas City concrete pavements, in the development of incipient cracks at their edges abreast end joints or cracks in the concrete gutter. Too great emphasis cannot be placed upon the fact that thermal changes represent one of the principal destructive factors in causing the disruption of well constructed monolithic pavements, and such influences deserve the most careful consideration on the part of paving engineers.

At Kansas City observations were made on the effects of wheel loads on different types of pavements, covering a range from water-bound macadam to grouted granite blocks. The observations consisted in measuring changes in the slope of the surface of the roadway which occurred in the immediate vicinity of one of the wheels of a truck, which carried a load of 5500 lbs. on its four wheels. Depressions and resiliencies were measured, on a chord of 12 inches, as the wheel loads were received and removed.

Differences in the behavior of the more rigid and the plastic materials were noted; variations as they appeared in different parts of the roadway, along the center line and near the curbs in the macadams, at places where the amount of binder was ample and where deficiencies existed; differences between the old and the new sheet asphalt, where there was a lack of continuity in the asphalt and bitulithic pavements; the behavior of grouted brick and concrete in the vicinity of and remote from

cracks or joints, at intersections where the regularity of the courses of the brick or stone was modified, noting the behavior of plastic materials which were sluggish in their response to wheel loads, both in respect to depressions and resiliencies, cases where flow of the material occurred at the edges of the treads of the wheels causing ridges to be raised instead of depressions in the immediate vicinity of the wheels,—all of these phases in the behavior of the different types of pavements were made the subject of observation.

Notwithstanding the number and variety of the conditions which were present, the results of the observations were concordant, and taking into account the number of variables which might influence the behavior of a pavement there was surprising regularity in the several types examined. The measured depressions or changes in slope appeared to be reliable indices of the physical condition of the pavements, each behaving with sufficient regularity to inspire confidence in the results and the method of their determination.

The tabular exhibit presented herewith shows the results on parts believed to be representative of the several kinds of pavements on which the observations were made. The resiliencies range from 0.0002″ to 0.0166″. The grouted granite, sandstone, brick, concrete, and some of the sheet asphalt displayed the greatest rigidity, and among these several kinds the more rigid examples of each gave substantially the same results. The macadam roadways, the wooden block, and the sand-filled brick comprised the more yielding pavements.

In general, the pavements responded immediately to the wheel loads, the full depression was immediately felt and the recovery took place at once when the wheel load was removed, the surface returning to its original slope without permanent set. In other cases there was a sluggish yielding of the pavement which continued for several minutes, followed by a sluggish recovery of like duration or attended with a permanent change in the slope.

It was noted on a water-bound macadam that the depressed area, or boundary of the depression about the place where the wheel stood, gradually increased in size when the load was allowed to remain stationary for a time. The radial extension

of the periphery of this affected area travelled at the rate of three inches per minute. A measurable depression was noted 16 inches from the point of contact with the wheel.

Instances in which a ridge of material was thrown up at the edge of the tire of the wheel, causing an elevation or slope from instead of toward the wheel, were followed by a slow recession of the crest after the load was removed. A granite macadam roadway which had shown varying durability in places was found to show corresponding differences in its behavior when loaded. Its varying characteristics as observed in these tests were in harmony with its behavior as a roadway. Deficiency of asphalt, as a binder, appeared to be largely responsible for its unsatisfactory condition.

Breaks in the continuity of the pavements, such as cracks in bitulithic and asphalt surfaces, and cracks in concrete slabs or in grouted granite blocks or grouted brick caused greater depression under wheel loads in their vicinity than displayed by intact portions of the same kinds of pavements. Differences were generally observable between the center and edges of macadam roadways. It seemed clear, from these observations, that certain streets which had shown good results in sustaining certain kinds of traffic had physical properties which made them suitable to carry such traffic.

The method of examination illustrated in these remarks appears capable of furnishing early and reliable information upon different kinds of pavements, indicating the character of the traffic which they would successfully sustain. Observations conducted with the necessary degree of refinement on the deformation of the materials, on the elastic and permanent effects due to wheel loads, and on thermal changes give promise of supplying early knowledge of the traffic values of different pavements, curtailing the interval of time which under present methods is necessary to determine the value of a pavement.

A number of observations of interest were made on the mobility of the surface of an asphalt macadam roadway, showing the formation of ridges and depressions, a creeping which occurred when the surface of the roadway was at a moderate temperature. It was found that the macadam was in slow but constant motion as regards vertical movement, forming ridges

in both crosswise and lengthwise directions of the roadway. A progressive change in the slope of the surface went on, in some places dipping in one direction, in other places showing reversed movement. These surface changes were observed on days in which the temperature of the pavement ranged from 50 to 60 degrees F. During the time of making the observations there was very little traffic on the street.

The continuance of these movements would eventually result in the formation of ridges noticeable to the unaided eye. This mobility of the asphalt macadam occurring at so moderate a temperature as experienced on the days of these observations is suggestive that thermal changes may share with traffic the responsibility for the formation of irregularities in the surface of pavements of this class.

Kansas City Pavements

Tabular exhibit of resiliencies, measured on a chord of 12 inches, when a wheel load approximately one-quarter of 5580 pounds was removed.

Comparative statement of the elastic recoveries of different pavements, referring to parts of the same which were representative of pavements, in good order, of the types mentioned:

Type of Pavement	Temp. degrees, F.	Street	Resiliencies Inches
Sheet asphalt, old	56°	Missouri Avenue	.0004 to .0012
Sheet asphalt	50°	Missouri Avenue	.0026 to .0032
Sheet asphalt, old	40°	Fifth Street	.0003 to .0005
Sheet asphalt	40°	Fifth Street	.0025 to .0032
Asphaltic concrete, new	33°	Eighth Street	.0007 to .0014
Asphaltic concrete, soft	33°	Eleventh Street	.0027 to .0046
Sheet asphalt, new	49°	Fifteenth Street	.0003 to .0013
Rock asphalt, laid 1901	45°	Twenty-second Street	.0009 to .0013
Sheet asphalt, new	57°	Cleveland Avenue	.0005 to .0011
Sheet asphalt	58°	Twenty-eighth Street	.0004 to .0011
Brick, grouted; recent work	59°	Third Street	.0010 to .0028
Brick, grouted; recent work	52°	Holmes Street	.0010 to .0017
Brick, grouted; laid in 1901	52°	Fourth Street	.0041 to .0067
Brick, grouted	47°	Fifth Street	.0010 to .0022
Brick, grouted	46°	Sixth Street	.0003 to .0010
Brick, sand-filled; 23 years old	39°	Thirteenth Street	.0032 to .0090
Brick, sand-filled	45°	Woodland Avenue	.0083 to .0166
Brick, grouted; laid in 1901	47°	Twenty-second Street	.0027 to .0100

Brick, grouted; laid one week	56°	Vine Street	.0007 to .0016
Concrete; has many ''chug holes''	45°	Sixth Street	.0003 to .0006
Concrete	45°	Twenty-second Street	.0002 to .0003
Concrete; 50-ft. roadway, 8" thick	54°	Thirty-first Street	.0002 to .0003
Concrete	60°	Twenty-third Street	.0003 to .0004
Wood block, creosoted; sand-filled	45°	Fourth Street	.0023 to .0088
Wood block, creosoted; asphalt joints	31°	Eighth Street	.0020 to .0085
Wood block; old; sand-filled	40°	Admiral Boulevard	.0018 to .0057
Bitulithic	38°	Admiral Boulevard	.0011 to .0017
Stone block; Kettle River sandstone, grouted	57°	Grand Avenue	.0011 to .0012
Stone block; Colorado sandstone, grouted	46°	St. Louis Avenue	.0004 to .0008
Stone block; Wisconsin granite, grouted	38°	Broadway	.0008 to .0019
Stone block; Kettle River sandstone, grouted	33°	Ninth Street	.0003 to .0011
Stone block; Medina sandstone, grouted	46°	Fifth Street	.0005
Waterbound macadam	56°	The Paseo	.0035 to .0065
Asphalt macadam	52°	The Paseo	.0042 to .0056
Asphalt macadam, granite	34°	Independence Boulevard	.0022 to .0072
Asphalt macadam	55°	17th St., Parade-Way	.0041 to .0055
Asphalt macadam	50°	Fifty-ninth Street	.0045 to .0063
Asphalt macadam	54°	Morningside Drive	.0058 to .0078
Tarvia macadam	44°	Huntington Road	.0047 to .0140
Tarvia macadam	60°	The Paseo, N. of 47th St.	.0010 to .0026

DISCUSSION

Mr. Mandigo.

Mr. Clark R. Mandigo,* Assoc. M. Am. Soc. C. E., (by letter) said that Mr. Howard had very clearly demonstrated the unavoidable destructive influences of temperature changes on cement grouted brick pavements. While experience has shown that following the precautions outlined in the paper, and using great care in construction, the defects due to thermal action can be materially reduced, there appears to be no practical way of entirely eliminating them. The question arises, therefore, whether the better pavement is to be secured with a grout filler used primarily to prevent the edges of the brick from chipping, or with some other joint filler, the chief function of which is to preserve the integrity of the pavement against temperature attacks. Cement grout will not perform both functions and in this dilemma he advocated square-edged brick without lugs, the joints of which are filled with a tough, adhesive asphaltic cement of low susceptibility to ordinary temperature changes. Close-jointed block pavements of all kinds show better wearing qualities than where wide joints are allowed, the blocks supporting one another; and the asphalt filler, when properly maintained, amply provides for expansion and contraction and protects, to a considerable extent, the edges of the brick.

With thick concrete monolithic pavement, conditions are somewhat different, due in part to the greater weight of the pavement slab and the rough sub-grade on which it rests. There is none of the progressive creeping of the pavement noted in a grouted brick surface. If the concrete can be forced to take the expansion by compressive strains without exceeding the elastic limit, the corresponding contraction will not be harmful. Mr. Howard's recommendation to omit expansion joints and to flatten the crown, has been found a very effective means of reducing thermal defects in concrete pavements. The concrete pavement of slabs 50 feet wide, 30 feet long and 8 inches thick, mentioned in the text, shows no defective thermal cracks after three years; the incipient cracks noted have not progressed in length and width. It should also be noted that the contraction observed on this pavement for a drop of 34° F. is considerably less than the theoretical contraction of free concrete.

Possessed of a knowledge of all the details of paving construction work in Kansas City in recent years, he felt convinced that resiliency measurements, as made by Mr. Howard on these same pavements, may be taken as a fair index of the standard of workmanship in their original construction and probably, therefore, of their relative durability. The better constructed the pavement and the better its condition at the time of testing, the more uniform was its resiliency in different parts under the same load. The more uniform resiliencies were toward the lower limit for each particular class of pavement and indicated the more rigid structure.

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* Ass't City Engineer, Kansas City, Mo.

Mr. Mandigo.

Municipal engineers have worked out accurate methods of selecting the materials entering a pavement, but have been obliged to wait on long-time service tests to determine the best method of construction. The intense traffic of the modern city soon discloses any weakness or lack of uniformity in the pavement structure, but this information would be much more desirable before the street was opened for travel. Mr. Howard's paper indicates the possibilities for usefulness of a careful scientific investigation of what goes on in a pavement under service conditions. He has given a glimpse of a field about which little of scientific value is known but which appears to be well worth searching, if durable and economical pavements are to be constructed. Information of this sort is needed to enable the engineer to give the necessary close attention to details in the design and construction of pavements which shall have the uniformity, rigidity, and durability required of modern city streets.

Paper No. 66

THE STRUGGLE AGAINST DUST.

By

C. C. DASSEN
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Buenos Aires, Argentina

The City of Buenos Aires has about 10,745,500 square meters (12,850,000 sq. yds.) of paved streets, among which 360,-000 square meters (430,500 sq. yds.) are in macadam.

This latter covering, the most expensive to maintain, is only found in the streets which connect the center of the city with ''Palermo'' the ''Bois de Boulogne'' of Buenos Aires.

The Municipal Administration has been desirous of making a special effort to keep these streets in the best condition for service, since the traffic is one of wealth and luxury; and among other things, the question of dust has constituted the principal care of the technical authorities. I shall indicate the procedure which the city has adopted with entirely favorable results.

The traffic by way of carriages and automobiles over this street is very considerable, while that of loaded wagons is forbidden. In order to prevent dust, use was made, some six years ago, of a system of sprinkling with water.

Experiments with a tar treatment, both hot and cold, with tar pure or mixed with petroleum residues, did not give the results desired. In the year 1908, private enterprise supplied the means for an experimental trial of cold oil, and the results being favorable, the Administration definitely adopted this method. Following are the details of the process.

The surface of the macadam, well sprinkled, is cleaned with brooms of ''piazzava'', thus removing loose sand and dirt. The mixture of oils is then poured on, sweeping along the excess which does not penetrate into the surface. The following day,

traffic is again permitted, and five days later the operation is repeated, after which the street is definitely opened for service.

The oiled surface retains the dust and should not be sprinkled with water under any conditions. The dust thus retained by the oil forms gradually a layer which becomes detached after a certain time. It then becomes necessary to oil again the spots thus affected. A special crew is designated for this purpose. If the work is carefully done the surface of macadam is preserved in good condition during a considerable period of time before it becomes necessary to repeat the general treatment.

It is naturally necessary to watch with care any sinking of the road due to lack of resistance in the foundation—a matter which has nothing to do with the care of the surface—but the oil treatment preserves the surface and insures a great saving in the expense of maintenance of the road.

It is readily seen that dirt thrown on the oiled surface will rapidly absorb the oil forming the layer, the loosening of which produces the need of retreatment. It is therefore necessary to prevent all traffic in wagons loaded with dirt, and also in water carts, since this liquid, by flotation, will bring the oil to the surface from between the stones and carry it away.

At crossings where the road must of necessity support the traffic of the neighboring streets, it is desirable, if these streets carry a heavy traffic, to substitute for the macadam some other form of pavement more resistant, although matching up with it. To this end, use may be recommended of concrete, asphaltic macadam with base of Bermuda asphalt, or of "gilsonite".

The oil employed is the Russian mazout. As this is very heavy and cannot penetrate between the stones, it must first be dissolved. To this end use is made of an oil named D. V., and of another equally light oil obtained from gas works and called "gazoil". These latter oils, being volatile, leave, in evaporating, the heavy oil behind. The evaporation of these light oils gives to the pavement a peculiar antiseptic odor.

The proportions of the mixture of the oils varies naturally according to atmospheric conditions. Cold weather calls naturally for an increased proportion of light oils. Under ordi-

nary conditions the mixture is made in the following proportions:

Mazout oil	0.60
"D. V." oil	0.30
Gazoil	0.10

Following are the costs in Buenos Aires: (The price is per kilo and in Argentine piasters*).

	1912	1913	1914
Mazout	0.14204	0.1693	0.1800
"D. V."	0.14653	0.1774	0.1680
Gazoil	0.13180	0.1719	0.1023

The first treatment of a square meter of macadam requires about one and one-half liters (0.396 gal.) of the mixture. At the present time nearly all of the macadam in Buenos Aires has been subjected to this process of oiling, and the investment cost amounts to approximately 0.43 piaster per square meter (1.76 cents per sq. ft.).

Following are certain statistical and economic results:

Oiling of Avenue Sarmiento Between the Avenues Alvear and Casares.
(Municipal undertaking)

Date, 1912. Area, 8000 sq. meters (9568 sq. yds.).

Materials employed—		
Mazout oil	8692 kg. (19,160 lb.) @0.14204 p. or	1234.26 p.
"D. V." oil	4116 kg. (9,072 lb.) @0.14659 p. or	600.93 p.
Gazoil oil	836 kg. (1,843 lb.) @0.1318 p. or	109.51 p.
		1944.70 p.
Labor—		
35 days @3.00 p. per day		105.00 p.
325 days @2.60 p. per day		845.00 p.
		2894.70 p.

This gives:

Cost of labor per sq. m.	0.12 p. (0.49c per sq. ft.)
Cost of material per sq. m.	0.24 p. (0.98c per sq. ft.)
Total	0.36 p. (1.37c per sq. ft.)

This work, carried out during the month of April, required during the month of May as follows:

* The value of the Argentine piaster is $0.44 U. S. gold.

Mazout oil	200	kg. (441 lbs.)
"D. V." oil	100	kg. (220 lbs.)
Gazoil oil	40	kg. (88 lbs.)
Labor	5.20	p.

During the month of September as follows:

Mazout oil	160	kg. (353 lbs.)
"D. V." oil	80	kg. (176 lbs.)
Gazoil oil	20	kg. (44 lbs.)
Special labor	2	days
Common labor	5	days

During the last three months of 1912 the expenses of upkeep were:

Mazout oil	1725	kg. (3802 lbs.)
Gazoil oil	965	kg. (2127 lbs.)
Special labor	1	day
Common labor	26	days

During the entire year of 1913 the cost of upkeep was:

Mazout oil	12,240	kg. (26,980 lbs.)
"D. V." oil	5315	kg. (11,715 lbs.)
Gazoil oil	650	kg. (1433 lbs.)
Labor—		
39 days		@3.50 p.
172 days		@2.50 p.

Oiling of Avenue Pedro Montt.

Date 1912. Area 13,082 sq. m. (15,650 sq. yds.)

Materials employed—

Mazout oil	12,600 kg.	(27,770 lbs.)	@0.14204 p.	or 1789.70 p.
"D. V." oil	6300 kg.	(13,890 lbs.)	@0.14659 p.	or 923.51 p.
Gazoil oil	1200 kg.	(2645 lbs.)	@0.13180 p.	or 158.16 p.
				2871.37 p.

Labor—

8 days @3.50 p. per day	28.00
89 days @2.50 p. per day	222.50
	3121.87 p.

Cost of work 0.24 p. per sq. meter (0.98c per sq. ft.)

During the remainder of the year, that is from May to December, 1912, the cost of upkeep has been as follows:

Labor—

6 days	@3.50 piasters
57 days	@2.50 piasters
Mazout oil	4875 kg. (10,745 lbs.)
"D. V." oil	2477 kg. (5460 lbs.)
Gazoil oil	180 kg. (397 lbs.)

During the year 1913 the cost was:

Labor—

55 days	@3.50 piasters
248 days	@2.50 piasters
Mazout oil	19,985 kg. (44,050 lbs.)
"D. V." oil	10,464 kg. (23,060 lbs.)
Gazoil oil	890 kg. (1962 lbs.)

Oiling of Iraola Avenue.

Date, June, 1912. Area 12,746 sq. m. (15,240 sq. yds.)

Materials used—

Mazout oil	13,120 kg.	(28,920 lbs.)	1863.56 p.
"D. V." oil	6560 kg.	(14,450 lbs.)	961.63 p.
Gazoil oil	1320 kg.	(2910 lbs.)	182.16 p.
			3030.15 p.

Labor—

8 days @ 3.50 p.	28.00 p.
62 days @ 2.50 p.	155.00 p.
	3213.15 p.

Cost of work per sq. m. 0.25 p. (1.02c per sq. ft.)

Cost of upkeep from July to December, 1912:

Labor—

8 days	@3.50 piasters
57 days	@2.50 piasters
Mazout oil	4825 kg. (10,635 lbs.)
"D. V." oil	2474 kg. (5453 lbs.)
Gazoil oil	245 kg. (540 lbs.)

During the year 1913 the cost of upkeep was as follows:

Labor—

53 days	@3.50 piasters
221 days	@2.50 piasters
Mazout oil	17,620 kg. (38,840 lbs.)
"D. V." oil	9220 kg. (20,320 lbs.)
Gazoil oil	930 kg. (2050 lbs.)

Oiling of Avenue Infanta Isabel.

Date, July, 1912. Area 18,000 sq. m. (21,530 sq. yds.)

Materials employed—

Mazout oil	8616 kg.	(18,990 lbs.)	1223.81 p.
"D. V." oil	4712 kg.	(10,386 lbs.)	690.77 p.
Gazoil oil	672 kg.	(1481 lbs.)	96.73 p.
			2011.31 p.

Labor—

9 days @ 3.50 p.	31.50
70 days @ 2.50 p.	175.00
	2217.81

Cost of work 0.12 p. per sq. m. (0.49c. per sq. ft.)

Cost of upkeep from July to December, 1912:

Labor—

8 days		@ 3.50 piasters
67 days		@ 2.50 piasters
Mazout oil	4113 kg.	(9066 lbs.)
"D. V." oil	2099 kg.	(4626 lbs.)
Gazoil oil	190 kg.	(419 lbs.)

During the year 1913 the cost of upkeep was as follows:

Labor—

81 days		@ 3.50 piasters
347 days		@ 2.50 piasters
Mazout oil	2613 kg.	(5759 lbs.)
"D. V." oil	14,594 kg.	(32,160 lbs.)
Gazoil oil	1270 kg.	(2799 lbs.)

Oiling of Vertiz Avenue.

Area (17,625 sq. m. (21,080 sq. yds.)

Materials employed—

Mazout oil	18,673 kg.	(41,160 lbs.)	2651.56 p.
"D. V." oil	8977 kg.	(19,790 lbs.)	1315.40 p.
Gazoil oil	330 kg.	(727 lbs.)	45.54 p.

Labor—

14 days @ 3.50 p.	49.00
108 days @ 2.50 p.	270.00
	4331.50 p.

Cost of work 0.25 p. per sq. m. (1.02c. per sq. ft.)

Finally in the accompanying table are given the costs of upkeep on all of the macadam subjected to this treatment.

They refer to the year 1914 and show a cost of 0.43 p. per square meter (1.76c per sq. ft.).

The oiling which is made the subject of this note requires special equipment as follows: Sprinklers, cars for the transport of oil, hand carts, pumps, storehouses, etc.

This system is considered excellent for all highways *de luxe* carrying a heavy traffic of carriages and automobiles.

NOTE ON RECENT PROGRESS IN IMPROVEMENTS OF STREETS AND PAVEMENTS IN BUENOS AIRES.

In the year 1810, epoch of the independence of the Argentine Republic, the city of Buenos Aires, which now has an area of 190,063,559 sq. meters (227,300,000 sq. yds.), counted only 7,000,000 sq. meters (8,372,000 sq. yds.). The actually populated zone, nevertheless, then as now, comprised only a sixth of the total area. Previous to 1780 paving was unknown. The difficulties of transporting the necessary stone were so great that, in spite of the success of a stone pavement constructed at that time, it was not until 1822 or 1824 that the paving of the principal streets was completed.

In 1890, or 25 years ago, these primitive pavements were still seen, consisting of large rough stones laid one against another on a foundation of earth or poor sand and interrupted with holes and deep ruts—veritable danger spots where drivers were often thrown from their seats. However, since 1865 there have been known in Buenos Aires streets paved with granite blocks 20 cm. long by 13 cm. wide and 15 cm. deep (8 in. x 5.1 in. x 5.9 in.), but they also were laid in poor sand.

Finally, toward 1895, there appeared the modern pavement on a concrete foundation. Before this date, in 1888, an attempt at wood pavement using fir blocks had not given satisfactory results on account of the poor quality of the wood.

The wood of the carob (''Algarrobo''), a native Argentine product and somewhat similar to the Australian ''karri'', was also tried in 1895 and with excellent results. Today there are upwards of 665,000 sq. meters (795,300 sq. yds.) of this pavement.

The area of granite pavement on concrete base is, at the present time, 7,400,000 sq. meters (8,850,000 sq. yds.).

Asphalt made its first appearance in 1895, according to the North American "Barber System", using Trinidad asphalt.

At the beginning of 1905 there were 502,676 sq. meters (601,150 sq. yds.) of American asphalt and 65,083 sq. meters (77,840 sq. yds.) of native asphalt (Seyssel, Ragusa).

Following is the present condition of the paving in Buenos Aires (Jan. 1, 1915):

Ordinary stone	424,663.30 sq. meters	(507,900 sq. yds.)
Macadam	360,000.00 sq. meters	(430,500 sq. yds.)
Asphalt Macadam	15,192.00 sq. meters	(181,700 sq. yds.)
Granite on sand	1,280,000.00 sq. meters	(1,531,000 sq. yds.)
Granite on cement	7,411,676.97 sq. meters	(8,864,000 sq. yds.)
Granite with asphalt joints	5,113.00 sq. meters	(6,115 sq. yds.)
Wood	665,373.48 sq. meters	(795,700 sq. yds.)
Trinidad Asphalt	502,676.23 sq. meters	(601,100 sq. yds.)
Native or European asphalt	65,083.05 sq. meters	(77,840 sq. yds.)
Small stone on concrete	942.90 sq. meters	(1,128 sq. yds.)

For the upkeep of pavements, the Administration possesses a large plant comprising two equipments for the preparation of Trinidad asphalt, one of which has a capacity of 1600 square meters (1914 sq. yds.) of area of asphalt, 5 cm. (1.97 in.) in thickness, or its equivalent of 1000 square meters (1196 sq. yds.) of area 5 cm. (1.97 in.) in thickness and 1000 square meters (1196 sq. yds.) of intermediate asphaltic concrete or binder of 3 cm. (1.18 in.) thickness, in a day of 9 hours of work.

The annual cost of upkeep amounts to more than 3,000,000 piasters Argentine.

For new construction, the annual expense may range from ten to twenty million piasters.

There is, further, a very modern and complete laboratory for the testing of materials.

In the following table are given the areas of new pavement work, year by year, since 1895 (including renewals of wood and asphalt):

1895	233,500.00 m^2	279,400 sq. yds.
1896	335,239.71 "	401,000 " "
1897	227,000.00 "	271,500 " "
1898	350,000.00 "	418,600 " "
1899	448,690.00 "	536,600 " "
1900	621,415.08 "	743,200 " "

1901	693,425.34 m²	829,400 sq. yds.
1902	181,714.30 "	217,300 " "
1903	96,795.14 "	115,800 " "
1904	229,631.08 "	274,600 " "
1905	96,460.18 "	115,400 " "
1906	275,103.00 "	329,000 " "
1907	345,754.83 "	413,500 " "
1908	580,640.43 "	694,400 " "
1909	492,439.22 "	588,900 " "
1910	725,289.58 "	867,400 " "
1911	677,609.10 "	810,400 " "
1912	1,082,655.67 "	1,295,000 " "
1913	1,061,157.66 "	1,269,000 " "
1914	883,788.03 "	1,057,000 " "

Cost of Maintenance of Macadam at Buenos Aires for the Year 1914.

Months	Personnel: Inspectors	Laborers 1st Class	Laborers 2nd Class	Section Bosses	Common Laborers	Amount of Wages Piasters	Materials: Oil in kg. Mazout	D. V.	Gazoil	Total Cost of Materials Piasters
January	30	60	30	30	863	2637.50	38,400	19,200	3800	10,526.34
February	30	60	30	30	880½	2703.55	20,982	9,362	1922	5,546.19
March	30	59	29	29	861½	2624.91	27,633	14,132	1440	7,596.02
April	30	60	30	30	862	2632.33	43,816	3,481	16866	10,197.07
May	30	59	29	29	861½	2667.50	19,860	9,996	1980	5,456.60
June	30	60	30	30	887	2697.50	32,608	16,656	3496	9,015.48
July	30	60	30	30	887	2697.50	32,960	16,480	3296	9,038.62
August	30	60	25	25	742	2306.66	19,412	9,706	1941	5,523.32
September	30	60	25	25	720	2251.66	24,814	12,407	2481	6,804.69
October	30	60	26	26	693	2186.83	18,200	9,100	1820	4,990.98
November	30	60	25	29½	683	2171.16	16,804	8,402	1680	4,608.11
December	30	60	25	30	677	2157.50	27,516	13,758	2751	7,545.64
	360	718	334	343½	9637½	29734.60	322,995	142,680	43483	86,949.06

Total cost of Personnel .... 29,734.60 p.
Total cost of Materials .... 86,949.06 p.
Total cost of Tools .... 384.00 p.

117,067.66 p.

General cost of Maintenance per square meter..........0.43 p.
General cost of Maintenance per square foot..........1.76 c.

Paper No. 67

THE FIRE PROTECTION OF CITIES.

By

JOHN R. FREEMAN

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SCOPE OF TOPIC.

The topic assigned to me covers broad fields of prevention and protection, which begin at the habits of the individual householder and do not end until we have passed by building laws, public fire departments and water supplies, and a thousand structural details.

A comprehensive treatise of city fire prevention should deal somewhat with city planning, with various police and fire regulations, and with the special value of water supplies that will supply enough direct hose streams for surrounding a conflagration; should cover the art of factory fire prevention, with the safeguarding of life in theatres, rules for safe electrical installation, the proper design and installation of automatic sprinklers, and of many other kinds of fire-fighting apparatus; but, above all, it should aim to promote the planning of an effective campaign of education for lessening the number of small fires, and for preventing small fires from becoming big fires, and should present an analysis of the costly object lessons found in fire records, which pass unheeded except by insurance men and fire officials.

All of these important and interesting matters would make a very thick book out of any really thorough-going treatise, and, obviously, nothing of that kind can be attempted in this paper. As exhibiting the scope and complexity of the subject, it may be worth while to mention that the printed record of papers and discussions at the First National Fire Prevention Convention, held in Philadelphia nearly two years ago, contains about six hundred closely printed pages, and that the Nineteenth Annual

Report of the National Fire Protection Association (May, 1915) comprises about five hundred pages, and these are merely current discussions of progress in the art.

Although much has been published on fire prevention and fire extinction, the best of it is scattered through many books and technical journals and in pamphlets published by insurance companies, and there is need of a volume that will condense and logically arrange all of this and more thoroughly expound the art.

In the time and space allotted here, I can only touch upon some of the high spots of the subject, and the need of brevity will compel a dogmatic statement of conclusions instead of analyses of statistics, of object lessons and of records of experiments.

IMPORTANCE OF THE PROBLEMS.

These problems of fire prevention in American cities are of profound importance. Year after year, with a surprisingly uniform rate of increase, the total yearly fire loss in the United States has mounted to upward of 225 million dollars per year, exclusive of the abnormal total in the year of the San Francisco conflagration. This sum has been pictured as equivalent to two continuous rows of houses, like those along both sides of a city street, more than a thousand miles long, or from Boston to Chicago, burned in every twelve months; and on top of the ordinary rate of destruction from widely scattered fires, there comes once in awhile a conflagration, as in Chicago, Boston, Lynn, Paterson, Waterburg, San Francisco, Baltimore, Chelsea and Salem.

To all of this loss there must be added the extra cost of public fire departments and water supplies, above and beyond what would be necessary with safer buildings; and thus the annual fire tax in the United States now averages but little short of a million dollars a day, year after year, and this in spite of all the good work and preaching done in the past ten or twenty years by insurance engineers and fire prevention organizations.

Statisticians report that the proportion of values burned yearly in the United States averages nearly ten times as great as in Europe, and that our fire losses per capita aggregate eight or ten times as great. To anyone who has studied conditions on

both sides of the Atlantic, it is plain that the excess of loss on this side is chiefly due to—1st, less careful habits; 2nd, less perfect laws; 3rd, less careful governmental supervision; 4th, to the fundamental differences in ordinary dwellings and city blocks, due to the necessity here of building largely of wood and building cheaply, while this country was new and both labor and capital were dear.

But in certain special lines, the problem of fire prevention has been solved better here in America than anywhere else in the world. Under the slow, scientific developments of half a century of factory fire protection, under the American Factory Mutual Insurance System, the typical cotton factory, in spite of wood floors and wood columns and inflammable stock, became long ago a safer risk than the average "fireproof" cotton factory of England; and the fire loss ratio in our large factories has become less than one-tenth part of what it was fifty years ago. This great improvement was brought about by arousing the mill owners to the economic value of safer structural details; such as the use of wood in the more fire-resistant form of heavy timbers and solid plank instead of joist and boards; by the opening to daylight, and to view, of dark or concealed hollows in which dirt might lodge or fire smoulder unseen or beyond reach; by systematic inspection for the enforcement of cleanliness and order; by ample private fire pumps and frequent fire hose, and above all, by the development of automatic sprinkler protection.

The same methods are applicable only in part to the broader problem of city fire prevention, but this remarkable demonstration of cutting out nine-tenths of the fire loss in factories by the means just stated shows where to take hold of the other problem most effectively, altho there is no hope here for a 90 per cent reduction.

In the fire protection of a city there is not the opportunity to reject the hopelessly defective risks, and a bad risk can menace many that are good. The menace of wide areas closely packed with wooden buildings will be with us in most of our cities for perhaps a century to come; the shingled-roof menace will persist probably for a quarter century, and the habits of neatness and care cannot be so effectually controlled in homes as in the factories. But notwithstanding this, there are grounds

for hope that our annual fire waste can be cut, say, at least in half; for the conflagration hazard has averaged only about twenty-five percent of the total loss, the number of small fires can surely be lessened, and with fewer small fires, there will be fewer general conflagrations started; and with hose streams from hydrants fed with larger volume and more pressure, conflagrations can be more promptly and more certainly controlled; but the low loss ratios of Europe are, in general, beyond our reach for a century to come.

The office-building districts of our large cities show great improvement during the past 20 years and contain many modern structures in which the risk, as measured by the insurance rate, is as small as in the most improved factories, but these comprise a small part of the total value and a very small part of the total area.

As one traverses the back streets, through the closely built territory of any American city, and observes the proximity of wooden walls, far enough apart to supply air to the flame but not giving space enough for firemen, and sees the rubbishy back yards, the projecting wooden eaves inviting ignition and the wide extent of shingle roofs, and reflects on what has happened, and how it happened, in Salem, Chelsea, Baltimore, San Francisco, Waterbury, Paterson, Lynn, Boston and Chicago, he can find in a hundred American cities, both small and large, that the kindlings and combustibles are all laid, ready for similar conflagrations whenever chance and circumstance make the right combination.

A BURDEN ON THE NATIONAL DEFENSE.

Should this country suffer hostile attack, its sea-coast cities invite destruction under the new arts of war, by bombs dropped from aeroplanes or dirigible balloons, to an extent vastly greater than the cities of those lands where the war is now raging.

In those cities the outer walls of most buildings are of brick or stone, the roofs are commonly of tile or slate, and instead of the hollow, cellular, quick-burning floors and partitions common with us, the corresponding floor and partition cells are in many of these foreign cities required by law to be filled wholly or in part with some fire retardant, largely composed of mortar or plaster-of-paris.

With us, cheap timber, scant capital, the economics of competition, the easy toleration of what is known to be risky, of building laws left lax in order to cheapen construction and stimulate building and help boom the town, have produced this condition that now confronts us when considering the national defense, and which condition now has an importance that was hardly dreamed of before Wright perfected the aeroplane, only seven years ago.

In our sea-coast cities, all the way from Eastport to St. Augustine, and from Seattle to San Diego, almost everywhere the conflagration conditions invite an attack intended to involve factories and warehouses in the sweep of the flames, and to promote demoralization by unhousing the populace.

It is reasonable to believe that our Navy could prevent the launching of such an attack, and that if by any possibility launched, such an attack from airships could be successfully met by special alertness, with buckets and casks previously distributed, etc., so that fires thus started could be quickly extinguished, particularly in those cities which have an ample gravity water supply, with large mains that can deliver simultaneously 25, 50 or 100 standard fire-hose streams directly from the hydrants without the intervention of fire engines; but it does no harm to look at the existing conditions and to let considerations of this kind help along the movement for safer building laws and for water supplies that can deliver good hose streams.

FIRES ARE LARGELY PREVENTABLE.

Most fires start from carelessness or in rubbish. They are fed mainly through false economies of construction. They get beyond control largely by neglect of precautions whose efficiency has been proved a thousand times. The fact that the trouble has its origin deep in easy-going human nature makes the remedy quite as much a problem of psychology as of engineering, for large improvement can only come from a long-continued, earnest campaign of education.

No one act would do more to improve the general safety than to pass and enforce ordinances for a systematic inspection of every house, shop and factory, attic, cellar and

closet, and thereby gradually arouse the owner or occupant to the dangers that he is imposing upon himself and his neighbors by carelessness. This would go far in lessening the number of fires.

But the work must go farther and provide prompt means for extinguishing those that still occur, before they get beyond the building in which they originate. The mechanical art of doing this in factories, stores and warehouses has been well developed in automatic sprinkler protection, but in dwellings which make up the greater part of all the buildings, these are impracticable and the main reliance must be the public fire department.

Beyond this, we have the problem of the conflagration, of surrounding and conquering the spread of a fire that has got out of the group where it originated and is beyond control. It will require a long education of public sentiment to support the heroic treatment often needed in more ample water supplies, more hydrants, the forcing in of sprinkler protection here and there, the subdivision by new, broad streets, and the imposing of an appropriate special tax on conflagration breeders.

The campaign of education has been going on for more than twenty years, and faster than ever before in the past five years, but still needs to be speeded up. The pupils heretofore have been mostly insurance men, engineers or manufacturers. It is necessary to interest the general public. It is one of the curious facts of psychology that when the time is ripe, great popular movements sometimes take a surprising start and gather force almost like a conflagration and we will hope that this time is coming soon.

SOME IMPROVED CONDITIONS.

The optimist, scanning the horizon broadly, finds, notwithstanding the steady increase in the total annual fire loss, that for ten or twenty years past many conditions have been improving. The outlook for greater safety against fire in American cities is brightening very distinctly in spots, but the spots are yet too small and much too far between.

In our chief cities the wonderfully rapid evolution of fireproof commercial buildings—more safely built in each suc-

ceeding year—is creating here and there some excellent conflagration barriers across the congested value districts; and now that city ordinances and insurance officials are becoming insistent about automatic sprinklers in many such buildings, we may expect that in the future those so protected will justify the name of "fireproof".

There have been several remarkable demonstrations that warehouse or factory buildings can be built conflagration-proof at a reasonable cost. One of the best was a four-story brick factory and warehouse of the Western Electric Company in San Francisco on Folsom Street at Hawthorne, which, although built with ordinary brick walls and plank and timber floors and roof, resisted an attack by the great San Francisco conflagration, first on one side and later on the other, and, practically uninjured, was ready for business the next morning, while everything around it was burned flat. The protection relied upon was wire glass windows and metal frames, shutters, automatic sprinklers and private fire pumps and fire systems and a few men on the inside with pails of water and dippers, although not all of these means of defense had to be put into use.

Another demonstration was found at the reinforced-concrete storehouse of the Naumkeag Cotton Mills, four stories in height, which stood fairly in the hottest path of the Salem fire of June, 1914, and came through without injury, thanks to the concrete, the inside automatic fire shutters, and the good design. This building also had sprinkler protection in reserve.

In industrial works the automatic sprinkler has revolutionized conditions of the fire hazards during the past thirty years, and systems of fire protections have been developed by slow processes of inquest, scientific experiment and evolution. In the cotton mills, woollen mills, paper mills, etc., covered by the insurance and inspection service of the Factory Mutual System, the improvement already referred to has been such that notwithstanding higher speed of machinery and greater crowding through of combustible stock—in textile mills and wood workers—more rapidly chemical processes in dye works and tanneries, the fire hazard has been reduced to one-tenth part of its former magnitude, being now on a broad

average less than one-twentieth of one percent of value per year; and the loss of life by fire in all of these thoughtfully protected factories—now numbering over three thousand and containing many hundreds of thousands of operators—all told, has been only five in all the past twenty-five years. These three thousand great factories, although valued at more than three billion dollars, comprise less than one-tenth in value of the country's insurance.

One of the most hopeful of all the signs of progress is the general awakening of the great stock insurance companies to deal with fire prevention. Working through the National Board of Fire Underwriters, their trained engineers have been thoroughly studying the general conditions of fire hazard throughout all of the chief American cities, and their advice, given freely, has been of very great value to municipal boards of public works and to public fire commissioners all over the land. The progress of schedule-rating by insurance companies for their larger risks has taught many owners the present dangers and the values of safeguards. Great good also has been accomplished by their support of the Underwriters' Laboratories for the study of fire-protection and fire-prevention devices, and in the organization, largely under their favoring auspices, of the National Fire Protective Association, composed largely of insurance inspectors, but with a good sprinkling of municipal building inspectors.

Public water works are being improved as to fire service largely through the educational influence of the conference of superintendents at their water works associations, and under the stimulating advice of the experts of the insurance companies. The State Insurance Commissioners are meeting together, formulating campaigns and beginning to collect statistics of the fire losses from different classes of risks. Improved building codes are making some progress, methods of fire department inspections from house to house are being successfully worked out in a few cities, but the field is vast and, as a whole, progress in results remains painfully slow. All of the progress and improvements mentioned above have not caused the curve of American total annual fire loss to begin on any pronounced downward trend.

SOME CONDITIONS WHICH HAVE NOT IMPROVED.

In almost every American city we have an inheritance from the past in acres upon acres of closely built wooden structures, on which the conflagration can feed when it breaks loose. Lax building laws and absence of reasonable restrictions as to open space between quick-burning buildings have vastly added to the fire hazard and to the ugliness of our communities and we are today in many cities adding to this bad inheritance for the next generation instead of lessening it.

It is a rule with real estate in cities, that in the onward march of time, neighborhoods mostly deteriorate, and that the spots are few and relatively small where land values so increase that old buildings are torn down to make way for new.

At some future time the methods of London, Glasgow, Birmingham, etc., in the expropriation of large tracts in the most squalid and hazardous sections of large cities, tearing down everything, replatting with broader streets, selling off the lots under restrictions at a profit or loss, will be accepted by the public on this side of the Atlantic and some fire barriers can be established thereby; but twenty years of occasional legislative agitation of ''excess condemnation'' has not yet given the application of these excellent principles a fair foothold in America, and this kind of relief from the conflagration hazard plainly will be very slow in coming.

The only practicable protection against this condition of quick and wide combustibility is that of extra costly water works, and extra complete and efficient public fire departments, and the development of such neatness and order as will lessen the number of small fires.

Meanwhile, we find, particularly in the manufacturing and commercial centers, a large influx of immigrants having lower standards of neatness than the immigrants of earlier days. We find in many cities an easy tolerance of unsafe conditions by the municipal councils and by political appointees, or by shortsighted ''boosters'' who would restrict nothing, lest it ''drive away business'' from their real estate or from their town, no less than by ignorant owners.

Thus it happens that those of us who dwell in the cities

subject to exposure hazards, rather than in the suburbs, after we have made sure that darkness, rubbish and dirt, chiefs of all incendiaries, have no lodgment on our own premises, find our homes and our places of work endangered by what goes on in some dangerous quarter a mile or more away.

One who has not been an eye witness of a great conflagration can hardly conceive of the irresistible force with which it spreads, or of the way in which great blazing fire brands are borne high aloft by the heated air currents, to be dropped in a dozen widely scattered spots at once, which may be a half mile or a mile away. Shingled roofs invite these fire brands, and when a conflagration is well started, even brick-walled and slate-roof dwellings ignite in a most surprising way, from heat radiated across the street, as I have personally witnessed.

Last year's conflagration at Salem, Mass., gives a good illustration of what may happen in some other city. This fire started in a small factory, under conditions so dangerous that no respectable insurance company, having the accurate knowledge obtainable by such inspection as should be part of its regular work, would have taken a chance on the risk as it was. It started under conditions obviously so bad that no intelligent municipal inspector of buildings or no respectable municipal fire department chief should have permitted the factory to operate even for a day without the best possible installation of automatic sprinklers, if, indeed, after discovering the conditions they had not prohibited this inflammable occupancy in so combustible a building within so congested a district. It was left for the spread of this fire to reveal the incompetence of the public fire department, and the weakness of the city's water works, most of which facts could have been discovered by any skilled investigator long before the fire.

As this Salem fire spread, it soon reached a lot of those triumphs of combustible architecture—"three-decker" wooden tenements, closely packed together—just such as are complacently tolerated in many American cities, on which the now raging conflagration fed without hindrance. Gathering strength, after a clean sweep of more than a mile, it finally attacked the broad front of a great brick cotton factory, which had been modernized and protected by automatic sprinklers,

and which, distrustful of the public water and hydrant service, had provided its own large fire pumps fed from the harbor, equal in capacity to five ordinary municipal steam fire engines. After a brave resistance, without the slightest aid from the municipal fire department or the municipal water supply, which it had paid large taxes to support, this factory also succumbed, largely because of a temporary derangement that stopped one of its fire pumps from feeding the automatic sprinklers at the most critical time. But against its well-designed storehouse the flames beat fiercely without gaining entrance, proving once more that warehouse buildings of moderate cost can be designed so as to withstand the fiercest conflagration.

Even the optimist, when summing up the improvements in fire prevention of the past ten or twenty years, must admit that the total annual fire loss in the United States progressively doubled in the twenty years from 1890 to 1910, and that for half a dozen years past has merely held about even, at the high-level.

SOME ECONOMIC CONSIDERATIONS.

When considering the future improvement of the fire hazard, it is hopeless to expect that, in the growth and spread of our cities, the buildings can individually be built of brick or of incombustible material or that they can be made as immune to setting on fire as those of Europe; and, meanwhile, one must not make too sweeping a condemnation of the use of wood in the building of American cities in the past. In a new country, with cheap lumber, dear labor and dear capital, it was sound economics to build cheap, cellular, quick-burning structures of combustible materials and "take a chance". True, they might in many cases have built better with no important increase of cost. And in thousands of cases now, and for many years to come, where buildings are small or can be separated, cheap wooden buildings will be justified.

Insurance statistics show that the inherent hazard of an ordinary wooden, quick-burning dwelling house is fairly small, and that their great danger in a city comes from proximity and from the hazard that one brings to another or that each presents to all.

Purely as a matter of impersonal economics and overlooking the personal discomfort to one householder in ten thousand, driven from home by a midnight fire, with loss of personal treasures rich in association, it is no worse to burn up a thousand dollars than to bury this sum beyond reach or recall in a needlessly fire-proofed structure.

Within limits, the quick-burning wooden house with cellular walls and shingled roofs still has its proper and economic field, and by certain inexpensive precautions of fire stops in hollow walls and care about the chimney flue, it can be made reasonably safe.

Conservation of capital is bound to be considered quite as much as other kinds of conservation, and we must not think yet of passing building laws that will make our American cities like European cities in freedom from homes built with cellular walls of combustible material.

Notwithstanding the enormous aggregate of fire losses already quoted, rising from about a hundred million dollars per year twenty-five years ago to more than two hundred million dollars in recent years, a study of the fire losses in comparison with the census values and the saving of capital or interest thereon by this cheaper construction would doubtless show that up to a certain point there had been economic gain from building as cheaply as practicable, and then letting insurance companies carry and distribute the risk.

The economic waste of the past has come chiefly in permitting the cheap combustible buildings to be crowded too closely against one another, and by delaying the restriction of wise building laws where the scattered village is becoming a closely built city.

A restriction made under the police powers of the municipality or the state in behalf of public safety, which forbade building any structure with wooden walls nearer than ten feet to the side or rear boundary of any lot, would have been of vast benefit, and in the long run the aggregate value of the lands would have been about the same. The same number of people would merely have been spread further apart; and there is lots of vacant land on the outer edge of most cities.

The economic waste that is now being nursed along comes

largely from the indifference of the public to such obvious hazards as the "three-decker" tenements of Salem (and those in a score of other cities), or from such short-sighted municipal policy as that which permitted once more the packing of two- and three-story wooden buildings closely together when rebuilding many parts of the burned district of San Francisco, and in general a wide-spread neglect of city planning and proper restrictions.

The time has now come when true economy can be found in laws that will compel safer building and in forbidding any man to place a quick-burning building in too close proximity to the building, or future building site, of his neighbor.

The cost of a fire-resistant structure of reinforced concrete throughout, for factory, warehouse or office, is now surprisingly little more than for a building with wooden floors. And there is good promise that a very few years more of experiment and invention will see it possible to build homes of moderate cost so largely of incombustible material that it will be true economy to insist on the type for closely built districts.

The additional expense of automatic sprinklers in almost any factory, shop or store where contents are combustible, is commonly nothing at all for buildings of large or medium size, when the decreased cost of insurance is counted in.

HOW CAN IMPROVEMENT BE HASTENED?

We must take the problem as we find it, human nature, deep-rooted habits, predominance of combustible architecture, personal economics, municipal poverty, false economy in building laws, bad politics, and all, and must recognize at the start that any immediate, wide-spread rebuilding is a practical impossibility. Many of the present defective structures will persist and remain more or less of a menace for 50 or 100 years to come. We must meet the conflagration hazard by lessening the number of small fires as well as by extravagant water supplies and extravagant fire departments.

For protecting existing buildings and their contents against fire, so far as relations of cost and utility will allow, or to the full extent that the traffic will bear, the mechanical problems are already well solved and well understood by many fire-preven-

tion engineers and by some municipal building inspectors in various parts of the land.

The present difficulty is to cause the public to make more use of this knowledge and to bring the present knowledge of the specialist into common use by building inspectors and fire department captains. For example, the average building inspector, like the average owner, fails to appreciate the vastly greater hazard of joisted construction as compared with slow-burning construction. The average fire department chief fails to appreciate the superior value of water works that can deliver, say, twenty to fifty or a hundred hose streams direct from hydrants. The average water-works superintendent hardly appreciates that in most American cities there are only half as many fire hydrants as there ought to be, and that in many places they stand too far apart. But with all these classes of officers charged with the public safety education is slowly making its way.

For new structures, the ten-year old art of reinforced-concrete construction gives us building material so safe and so cheap and so thoroughly practical for factories and commercial buildings, that we need look no further, and with Mr. Edison, I have full faith and belief that means can be, and soon will be, worked out for using this in building fire-proof and rat-proof homes of moderate cost.

The automatic sprinkler has proved its practical efficiency in preventing small fires from becoming big fires more than a thousand times over during the past thirty years, and has furnished such cheap and efficient means for protecting stores, work-shops and commercial buildings that the chief problem is that of compelling their introduction by law.

SYSTEMATIC INSPECTION.

First of all in importance in easy practicability, economy and in educational value for lessening the annual fire waste in cities is a systematic inspection service.

The feasibility and economy of inspection service in fire prevention, and the fact that disorder, neglect, dark corners and dirt are the worst of all incendiaries has been amply demonstrated by the experience of the Factory Mutuals during the past half century.

Perhaps the sentiment that a man's home is his castle may be humored, while he promotes fire hazard by neglect, so long as he dwells apart from other men, but plainly in a thickly built-up neighborhood the man who hazards his neighbor's home should be shown up and punished and forced to reform.

The force can be exerted, first, through his information; next, through an appeal to his self-respect; next, by admonition from police and by increased insurance rates, and perhaps even by the levy of a special municipal fire tax. Although novel, this would make the punishment fit the crime, and would simply partly reimburse the municipality for the extra expense in fire department maintenance caused in the protection of neighboring property against this conflagration breeder.

Systematic, house-to-house inspection by members of the regular city fire department has been inaugurated in several American cities during the past few years, notably in New York, Philadelphia, Chicago, Cincinnati, Kansas City, Rochester, Columbus, Lansing and a few others,—everywhere with most encouraging results, and with very slight additional cost to the municipality. Where properly planned and administered, it is found that the firemen do not resent the work as an additional burden imposed, but enjoy and welcome their assignment in rotation to this duty.

From the experience thus gained, and also as a matter of common sense, it appears plain, beyond all doubt or question, that every city in America having a paid fire department should inaugurate this kind of service, after studying the best of the systems in use in the cities named and adopting whatever is found best suited to the local needs. This one matter—systematic inspection of every building in every fire district, not less than from one to four times a year—is, I believe, the most effective single remedy for lessening the fire hazard of American cities.

FORCING SPRINKLER PROTECTION.

Second in order of importance I would place legislation for enforcing protection by automatic sprinklers in all buildings within crowded fire districts, where expert special inspection shows that conditions are specially hazardous by reason

of occupancy, area, height, or quick-burning character of construction.

A movement in this direction has already been begun in New York, and might well be inaugurated in every city or closely built village, wherever conditions are found that hazard the neighboring property of other owners or that might, under adverse circumstances, breed a conflagration.

BUILDING CODES.

Third in order of importance is the matter of good building laws.

Good work in the formulation of a model building law that might be prudently adopted throughout the land, and specially adapted to the need of small communities, has been recently done by the National Fire Prevention Association, and the problem has received attention from eminent authorities on behalf of the American Institute of Architects and by various State Boards.

The principal requirements for safety are well known; the delays seem chiefly due to petty matters of detail, about preference for one structural material over another, as for reinforced concrete over hollow tile, or over the merits of one patented floor system as compared with another, or over unit stresses to be allowed in certain types of construction.

Plainly, common sense dictates that each state should formulate a common general code, and each city adopt this, with such extensions or amendments as local conditions may justify, and leave some minute perfection of detail to the future, after a few years' experience.

The public welfare would be well served if all would unite in trying out the code worked out by the N. F. P. A., unless they already have a more elaborate and more perfect one of their own, and the next thing is to see to it that the provisions of the code are rigorously enforced.

INSURANCE INSPECTIONS.

Fourth, insurance companies, in general, might with great advantage unite on more efficient inspection service of their smaller risks and dwellings through local boards and through

special inspectors of the National Board, which should supplement the regular fire department inspectors already referred to, and by at least an annual inspection give the home office a more accurate measure of the hazard of the smaller risks and at the same time give the home office a close line upon the efficiency with which the proposed municipal inspection is being carried on.

Their larger risks are now fairly well looked after, and schedule-rating is bound to, in time, have an important effect in reducing the general fire loss; but for the small risk, the small premium affords no margin, under present conditions, for distinguishing between the property of the negligent and that of the careful owner or tenant, or for penalizing the man who hazards his own and his neighbor's property by increasing his rate of premium. This problem of providing means for insurance inspection of the small risks is not an easy one, but it is believed some kind of cooperation between municipal and insurance inspection could in time be worked out that would be helpful.

Although insurance is primarily not fire prevention, but the science of averages and distribution of losses and of estimating risks as one finds them, a new and broader conception of the insurance business is now fast developing, and the old fear of the agent's that to recommend improvements might cut his compensation or commission in half is becoming uprooted, by closer relations between the Home Office and its risks, and by various means of reward to the discriminating agent.

The National Board, representing the stock insurance companies of the country, has been doing noble work by its expert inspection of the chief cities of the country as to water supply and fire departments, by electrical inspections, by good advice on building codes and as to general conditions affecting conflagrations in each particular city; and in most cases the heads of city departments have welcomed this free expert assistance, and city councils have been acting upon the recommendations as fast as funds available would allow.

As to the better grade of industrial plants, the field is being admirably looked after and cared for by the great insurance organizations—stock and mutual—who, though competing for

business, are fairly unanimous as to what is essential to safety, and today the majority of large textile mills, machine shops, paper mills, and the like, present the smallest hazard to property in building and contents and smallest fire hazard to life of operatives from fire, of any factories in the world.

Some four thousand of these factories, with aggregate values upward of four billion dollars, are insured at an annual cost, including fire hazard, administration and expert inspection service, for one tenth to one twentieth of one percent per year; and almost every one of these "risks" is a help rather than a menace to the safety of the community in which it stands.

ENGINEERING DETAILS.

Of the mechanical and engineering details of fire prevention, there is here no space for discussion.

The fundamental principles have all been thoroughly worked out and are matters of common knowledge among insurance inspectors and fire-protection engineers. No new mechanical inventions are needed for making our American cities safer against fire. The invention needed is that of how to more effectually arouse the public—how to stir legislatures and city councils to more efficient work in promoting neatness, order and general care by laws and ordinances for fire department and police inspection; by increasing public sentiment for up-to-date building codes and their enforcement; by laws for compelling automatic sprinklers wherever needed for the protection of life or for the safety of the neighbors' property; by laws for absolutely prohibiting any more wooden shingles on roofs within closely built districts; and for educating and arousing the general public to take more interest in such activities and measures for the common good.

CONCLUSIONS ON THE BEST PRACTICAL MEANS OF PROTECTING A CITY AGAINST FIRE.

In the brief paragraphs below I have summarized in a broad, general way the lines of effort that I believe would be most effective. None involve much expense in proportion to the value to be secured; as already said, the lessening of the great American fire waste rests more upon psychology or hu-

man nature than upon mechanics. The development of a public sentiment that would pass and support the following measures would probably cut the American fire waste at least in half.

(1) An extension of the public fire department service to the systematic inspection of every room in every individual building.

(2) Forcing automatic sprinkler protection wherever the fire commissioner of a city or state deemed the conditions hazardous to the property of neighbors, or to life of occupants.

(3) The adoption and enforcement of good building laws in cities and villages wherever now inadequate, forbidding all extensions of shingled roofs in cities or villages, and perhaps going beyond the scope of most present codes by forbidding any more wooden buildings within ten feet of the boundary of a lot, and forbidding wooden walls more than two stories or twenty-five feet in height nearer than forty feet to a property line.

(4) A better supervision by insurance companies of their smaller risks.

(5) A more systematic, more widespread and more efficient education of the public at large in matters of fire hazard and in the benefits of neatness and order. This will require great effort and patience in the beginning; but when measures (1), (3) and (4) have been secured, the further education will automatically follow their wise administration.

(6) A National (or State) service of inspection and public information (educational and advisory rather than mandatory, or somewhat like the work of the experts of the National Board of Fire Underwriters), which should be charged with overlooking the work of the various municipal fire departments and building departments and their inspectors and systems and with aiding in co-ordinating their work, and also be charged with making critical reports upon the degree of efficiency found in these local departments and with making recommendations, where found necessary, of means for improving it.

DISCUSSION

Mr. M. M. O'Shaughnessy,* M. Am. Soc. C. E., expressed the belief that San Francisco has the best fire protection system in the United States. The system uses fresh water, but is connected with salt-water supply for emergency. There are two pumping stations for the auxiliary salt water, one in the city and the other at Fort Mason. The one at Fort Mason has a gallery under the sea for intake, with the boilers and pumps kept in readiness for instant duty. There are large pipe lines leading from the station to the city system. In connection with the system is the fresh-water reservoir at Twin Peaks, at a height of 735 feet above sea-level. Mr. O'Shaughnessy.

Mr. T. W. Ransom,**M. Am. Soc. C. E., thought that possibly small cities are going too far in the matter of fire protection. The high pressure system is only applicable in large cities. In the former case, a better result would be obtained by using fire hydrants at more frequent intervals and under lower pressure. The handling of high-pressure fire streams requires trained men and a large fire department. Seventy-five pounds per square inch should be high enough pressure for the smaller towns, as compared with the 300 lbs. per square inch used in San Francisco. He desired to ask Mr. Freeman whether he considers that the automatic-sprinkler system should be connected in on the high-pressure fire system in any city. The Fire Underwriters on the Pacific Coast object to such a connection. Mr. Ransom.

Mr. C. E. Grunsky,†† M. Am. Soc. C. E., called attention to the large amount of wooden structures in San Francisco and the resulting fire hazard. He pointed out that in 1902 the Merchant's Association had investigated the fire system and advocated a high-pressure installation at that time, while he, himself, being City Engineer at the time, had laid out some of the plans which were later embodied in the present fire system. Mr. Grunsky.

Mr. Freeman, replying to various questions, expressed the opinion that in general it is good practice to connect the two systems, except in the case of extremely high pressures. Mr. Freeman.

In the planning of fire systems, hydrants should not be placed too far apart. The delay and wear and tear of hose over the longer distance is more expensive than extra hydrants. As has been said, many low-pressure streams playing upon a fire are more desirable than fewer high-pressure streams. Quantity of water is the desirable feature in fire protection.

Regarding the fire-proofing of wood, he noted that the operation usually implies the saturation of the material with ammonium phosphate. The action does not result in fire-proofing in the proper sense, but rather in increasing the difficulty of ignition. He had found by experiment on

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** Cons. Mech. Engr., Board of Public Works, San Francisco, Calif.

†† Cons. Engr., San Francisco, Calif.

Mr. Freeman. scenery after the Iroquois Theatre disaster in Chicago that so-called fire-proofing methods used on fabric merely delay ignition. The fabrics can be wholly consumed.

Mr. Taft. **Mr. H. S. Taft**† (by letter) referred to Mr. Freeman's statement that most fires not only start from carelessness, but when once started feed on the same, carelessness being ''fire fodder''. He believed it to be a fact that most of the large conflagrations experienced in this country have had their origin in carelessness and have found their ''fodder'' in the cellular wooden construction lying in their path. In our largest cities, wooden construction of an inflammable nature should be absolutely prohibited and all such buildings now in existence should be eliminated as soon as possible. But in certain sections of our country, as on the frontier, a cheap wooden structure, or in some cases even a canvas tent, is almost a necessity. Later, with increasing capital, buildings of a more substantial character, though scarcely yet fire-proof, may be built; and thus through continued progress, and with adequate growth, genuine fire-proof construction becomes a reality. Nevertheless, these conditions should not permit the deliberate upbuilding of a non-fireproof community of large size nor should it justify the deliberate building of a fire trap next to a slow-burning warehouse of mill construction or better.

Regarding the paper in general, Mr. Taft was impressed with the fact that the author had referred rather to structures standing on terra firma than to those built over a water surface, though perhaps the word warehouse, as used, would cover such a situation. He believed that the author of the paper would agree with him that there can be no worse place for a conflagration to start than along a city water-front, with the type of wooden docks so commonly found in most of our ports. In such case it is almost impossible for the fighting force to properly surround the burning structure or structures with their fire-fighting apparatus, and the whole structure is liable to collapse at any moment and precipitate all thereupon into the water underneath, possibly with a serious loss of life.

He considered that the type of fire most feared by firemen is the cellar or basement fire among inflammable materials, giving off a heavy gaseous smoke in burning, a location to which there are usually but few means of access. This is the more to be dreaded when the construction is of wood, whereby the destruction of the basement columns may permit the collapse of the entire structure before the flames have broken through into the upper stories, in spite of the fact that sprinklers may exist on said upper floors; though the basement is generally the first place where sprinklers should be installed.

In wooden dock construction, in spite of the extensive layout of sprinklers and other fire-extinguishing means provided to prevent the spread of a fire (if such should start among the goods stored therein) no

† Contracting Engr., Seattle, Wash.

system of fire prevention has hitherto been considered necessary for preventing the starting of a fire on the underside of the decking, or of the spread of such a fire if once started, with the collapse of the entire sub-structure and the consequent destruction of the superstructure, before the flames have broken through into the superstructure, or before the interior sprinkling system has been brought into operation. Mr. Taft.

While the destruction of an old wooden dock structure by fire may be a small matter in itself and an economical method of getting it out of the way for a new one, when consideration is given to the amount of merchandise usually stored on a dock, to the possible destruction of neighboring docks, buildings and shipping, the interruption of business as well as the loss of revenue while rebuilding, it is seen that a big dock fire becomes a very serious matter for any shipping community, affecting a larger number than almost any other type of fire.

Space did not permit of a detailed discussion of the causes and effects of the disastrous dock fires at Hoboken, New Orleans, Newport, New Brunswick, Portland, Seattle and other ports during past years. Some started from causes above the deck, others from causes from below the deck, others from causes on the vessel lying alongside. While the loss from such fires may be covered by insurance, it cannot be denied that they represent an economic loss to the whole community and not alone to an individual.

He pointed out that creosoted lumber will take fire and, in burning, produce a heavy, black, gaseous smoke, which collecting under the deck of a dock or in the enclosed superstructure may, when sufficiently heated, suddenly ignite and spread the fire with great rapidity throughout the entire dock structure, as has been established in at least one serious dock fire on the Pacific Coast, with another in a foreign port. While fire-stops, sprinkler systems, etc., as spoken of by Mr. Freeman, may be successfully used to prevent the spread of a fire, it is the elimination of the causes that start the first ignition, or the elimination of attack on the structure itself by the first ignition that is the real problem.

Also, now that fuel oil has become such a universal fuel in the merchant marine, fire risks around our docks from such a cause must be seriously considered by dock as well as fire insurance engineers. Though the possibility may be disputed, nevertheless fuel oil when spread out over a water surface has taken fire on at least one occasion. Serious explosions have also taken place from the gaseous material flowing into sewers from garages. A very general complaint in present times, as respects our harbors, is the amount of oily matter floating about under the docks, especially should an oil burner be accidentally sunk at the dock site, as was recently the case at a Puget Sound port, by ramming on the part of another vessel. The fire hazard created by such a condition can be better imagined than expressed in dollars and cents.

He observed that while concrete construction, as Mr. Freeman states, may be a very economical undertaking on terra firma, the use of concrete for a dock structure—substructure as well as superstructure—pre-

Mr. Taft. sents serious questions of both a structural and economic nature. While a depth of water of 75 ft. at high tide at a distance of less than 700 feet from the bulkhead line, with a maximum tidal range of 18 ft., such as exists at some Puget Sound ports, may absolutely prohibit the use of concrete in the construction of fire-proof docks in such locations, its use as a substitute for an inflammable material in the dock work of such ports as New York, Boston, Philadelphia, Baltimore and New Orleans, where the teredo do not exist, or in ports where the water is only of sufficient depth to permit the docking of a ship of ordinary size, is to be recommended.

The use of a concrete deck slab supported by wooden piles, as has been widely used in New York City, cannot be considered in the same class of fire-proof dock structure as the system spoken of above. While such a type of structure protects, with its sprinkler system, the goods stored therein, the entire fire-proof part of the structure is open to destruction from fire causes underneath the dock.

It is true that overheated concrete may spall off like stone when subjected to water and perhaps cause failure thereby. Still it is not the small insignificant blaze among a group of piles or the ignition of a small quantity of oil that may bring about the destruction of the dock, but rather the fact that such an ignition may take place among highly inflammable materials. It is the prevention of the fire extending to the pile structure that he had in mind, not the extinguishing or confining of the blaze when once started.

Mr. Taft expressed himself as fully in agreement with Mr. Freeman as to the necessity of a wide-open campaign of publicity for the imparting of fire-prevention knowledge to the public.

Paper No. 68

ARCH BRIDGES OF HOOPED CONCRETE WITH CAST IRON REINFORCEMENT.

By

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The use of steel with concrete was employed with a view to increasing the security under tensile stress. Nevertheless, in the beginning, those applications of reinforced concrete were favored in which tension was only incidentally a factor of the problem, and which therefore in small dimensions could have been carried out in concrete alone, as, for example, in arch bridges, the oldest example of which, a culvert, 16.5 m. (54.1 ft.) in length, was built in 1875 in France. The building of longer spans, and therewith the introduction of this material into genuine bridge construction, was undertaken in Germany and Switzerland first in 1890. [The ''Ausstellungsbrücke'' in Hamburg of 40 m. (131 ft) span, and a road bridge in Wildegg of 39 m. (128 ft.) span].

This cautious development and also the retention of girders in the construction are explained by the slow development of information regarding the co-working of these materials in tension. This situation must be kept in mind in order to appreciate the importance of Professor Melan's proposals for the construction of arch bridges. In order to meet the objection made at that time to the use of flexible reinforcement, Melan reinforced the concrete arch with steel I beams, and thus furnished the first example of the combination of steel and concrete in compression. When I visited the Chicago Exposition in 1894, I found concrete not yet recognized as a structural material in the United States. Because of the limited extent of cement construction, due to the lack of large cement factories, I considered the use of the Monier

arch not practicable at that time, and at several points in the United States I proposed the Melan arch, which moreover could be carried out with less experienced labor. After publishing the article, "Concrete-iron Highway Bridges" in the Transactions of the A. S. C. E., 1894, I succeeded, later in the same year, in building an arch of this kind of 70 ft. (21.3 m.) span in Eden Park, Cincinnati, Ohio, and one of 100 ft. (30.5 m.) span at Stockbridge, Massachusetts.* These are the first reinforced-concrete bridges in the United States, and with them reinforced concrete was introduced into American bridge construction.

My New York office, which later passed into the hands of my collaborator, Mr. W. Meuser, C. E., developed these beginnings further, so that today the number of arch spans in the United States, belonging to the Melan and similar systems, is estimated at 5000. This development proves that the Melan system has many good points, which, later on, as well, were able to gain recognition, in spite of the advantages of the arch with flexible reinforcement.

As I pointed out at the beginning of this paper, the use of steel with concrete was intended only as a reinforcement for tension. It would therefore come into question in concrete arches only in those parts and in corresponding measure, where greater tensions occur than the concrete alone can bear. For the next decade, the development of reinforced concrete was continued along this line, leading to the greatly extended use of reinforced concrete beams which marks the practice of today. On this stage of the development of reinforced concrete I have made a report in a paper† presented at the World's Fair of 1904 in St. Louis.

As the knowledge of the effect produced by steel in increasing the tensile strength of concrete construction progressed, it was recognized that in the case of certain structural parts, its compressive strength as well required reinforcement.‡

While in the first applications of reinforced concrete the compressive strength of ordinary concrete was considered sufficient, more recent efforts were directed to making sections of

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* See Engineering News and Engineering Record, 1895, for description.

† "Improvements of Concrete-steel Bridges", Transactions A. S. C. E., 1904.

‡ Über die Berechnung beiderseits Armierter Betonbalken", Separat abdruck "Beton u. Eisen", 1903.

reinforced concrete for high compressive loads and thus to use higher compressive stresses than the concrete alone will permit. This applies especially to the construction of heavily loaded columns,† parapet bridges‡ (Fig. 2) and arch ribs. This last construction I will treat of briefly by means of particular examples. The use of flexible longitudinal steel reinforcement in a compression member was at first generally considered not good practice, and to be avoided where possible on account of the bursting effect on the outer fiber. This view is presented most forcibly in the "Schweizer Vorschrift für Eisenbeton", 1908. All regulations favor for this purpose the spiral hooping invented by Considère, the operation of which is shown in Figure 1, for a cross-section of which we will represent the total section by F_g, the core section by F_i and the reinforcement section by F_{st}. If we now suppose a core banded with an amount of steel F_h we obtain the increase in compressive strength of such columns as shown in Fig. 1. These have either the carrying strength

$$P = F_{st}\,\sigma_{st} + F_g\,\sigma_c \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

in which σ_{st} represents the stress at the elastic limit for steel, and σ_c the crushing strength of concrete; or with higher hooping we have, on account of the influence of the core, the strength

$$P = F_{st}\,\sigma_{st} + F_i\,\sigma_c\left(1 + 40\frac{F_h}{F_i}\right) \quad . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

The increase produced by F_h depends not only upon the cross-section of the hooping but also upon various other circumstances.

In a practical application of the method the increase may be placed at 40% for every 1% F_h (in relation to F_i). With careful workmanship, the use of hard steel for the hooping irons and other means, it may be raised to 80%. This corresponds nearly to the 30% increase for F_g given in the regulations. It must not be overlooked that the effect produced by these hoops does not appear before the period of rupture is reached, and only in this way increases the strength.* To make this obvious, equation (2)

† Beton u. Eisen, 1913. "Beschreibung des Ericson Gebäudes mit Säulen aus umschnürten Gusseisen".

‡ See "Neuen Bogenbrücken", Berlin, 1913. No. 46, part 46-49.

* See part 28 of the report d. D. A. f. E. B. or Beton und Eisen, 1915, No. 49.

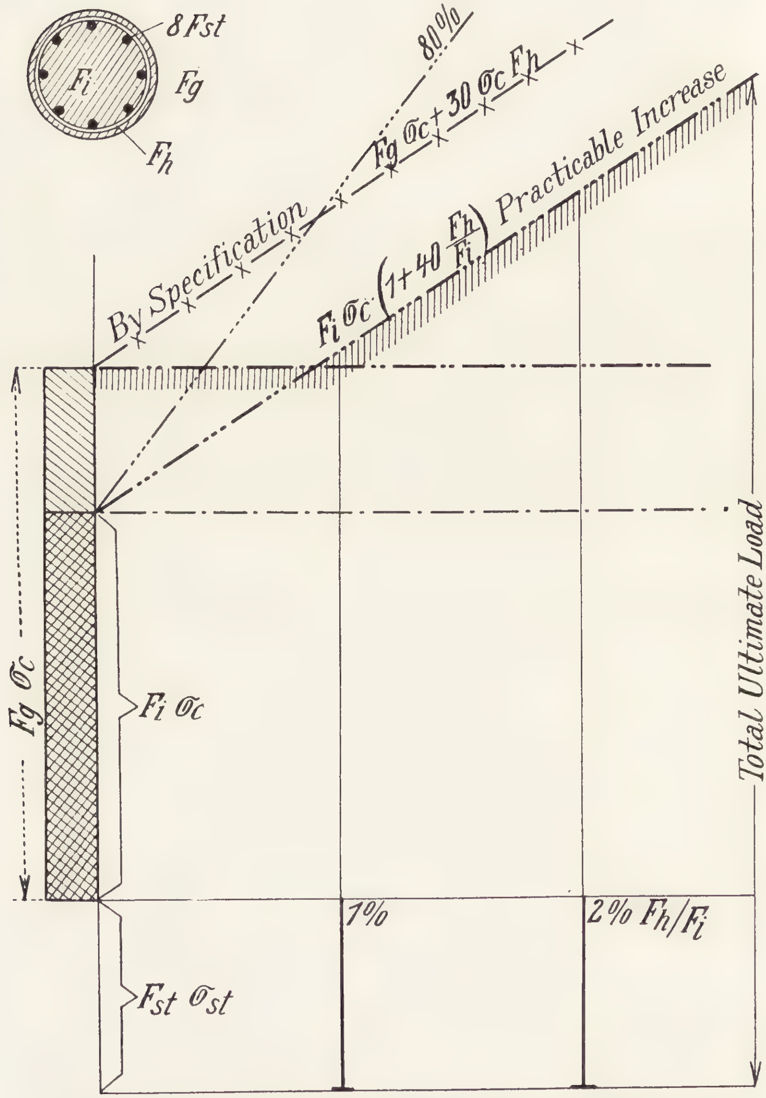


Fig. 1. Increase in Compressive Strength of Columns Due to Spiral Hooping.

is written in such a way that we see what part of the load rests upon the concrete F_i and what upon the steel F_{st}. It is a widely spread error to suppose that for columns computed according to the equation which continues to be found in all regulations,

$$P = \sigma_c F_g + 15 \sigma_c F_{st} + 30 \sigma_c F_h \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

a value for σ_c of, for instance, only 600 lbs. per sq. in. (42 kg/cm²) is suitable. That is incorrect, for the cross-section F_h, used for hooping, carries no load. If for example F_h amounts to 2% and $\sigma_c = 42$ kg/cm², then the allowed value is given by the equation

$$\sigma_c \left(1 + 30 \frac{F_h}{F_g}\right) = 1.6\, \sigma_c = 67.5 \text{ kg/cm}^2 \text{ (960 lbs. per sq. in.)}$$

and the column is actually loaded to this amount on its total surface. It should be observed that if the concrete, as frequently happens, has 960 lbs. per sq. in. compressive strength, the column breaks without the hooping producing any effect, because in the actual construction not nearly so great an ultimate compressive deformation is allowed as is shown by a bridge with hooped girt (Fig. 2), which gave way for this reason. The poor concrete caused great compressive changes which led, as a consequence, to the destruction of the entire bridge. The curves of compressive change which I have shown on several occasions give a very clear idea of the distribution of the load (Figure 3a). They also show plainly the effect of hooping on compression and on the strength of the concrete. The run of the curves is at first independent of the hooping. Not until after the destruction of the unreinforced shell does the influence of the hooping manifest itself, in that from now on the concrete shows large compression for a comparatively small increase in strength.* This increase depends (aside from F_h, Figure 1) to a great degree upon the care taken in the work, as well as upon the form of the hooping and the properties of the materials used in the hooping bands. A slight inequality within the concrete section results in unequal compression and therefore in a bending of the column. Such conditions bring about a sensibility to buckling not present under other circumstances, which explains the fact that a hooped section without adequate longitudinal reinforcement is looked upon

* See ''Neue Bogenbrücken aus umschnürten Gusseisen'', Berlin, 1913, W. Ernst u. Sohn, p. 30, part 28.

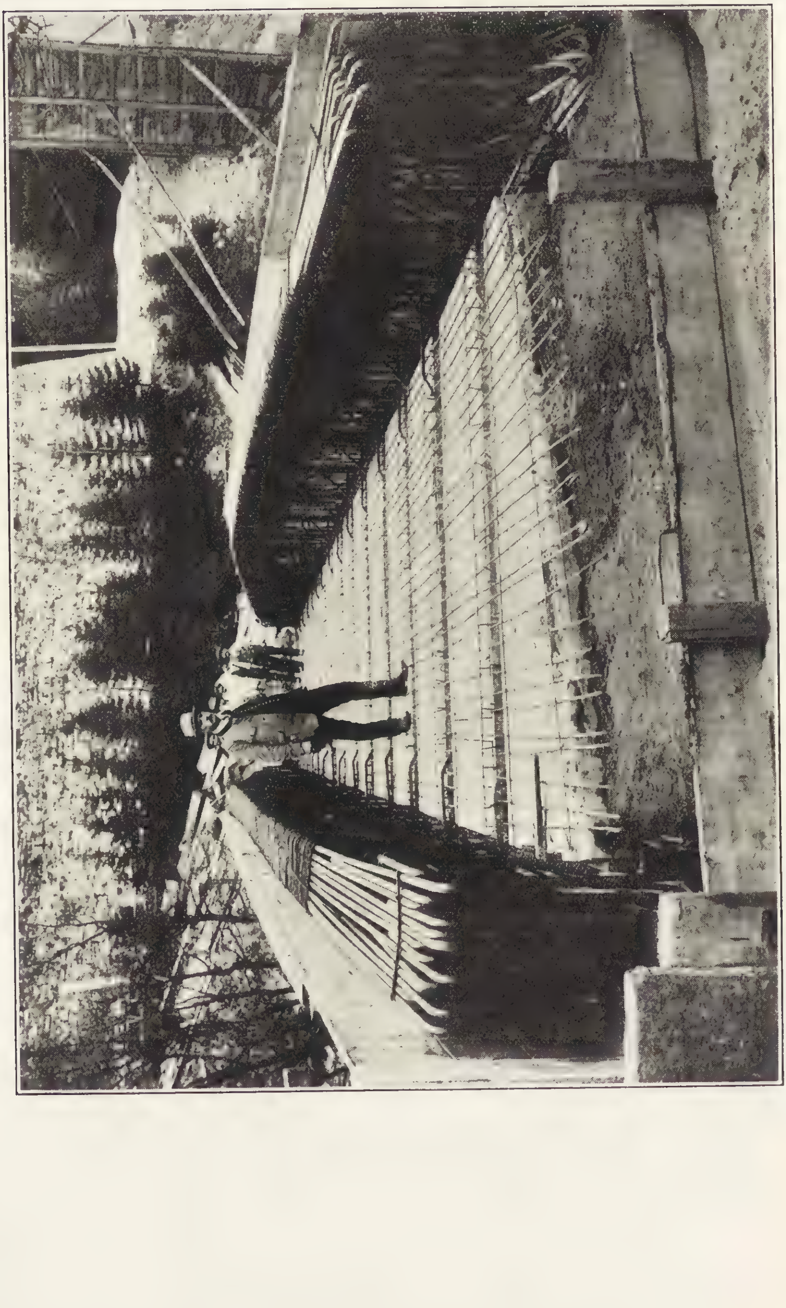


Fig. 2. Reinforced Concrete Girder Bridge.

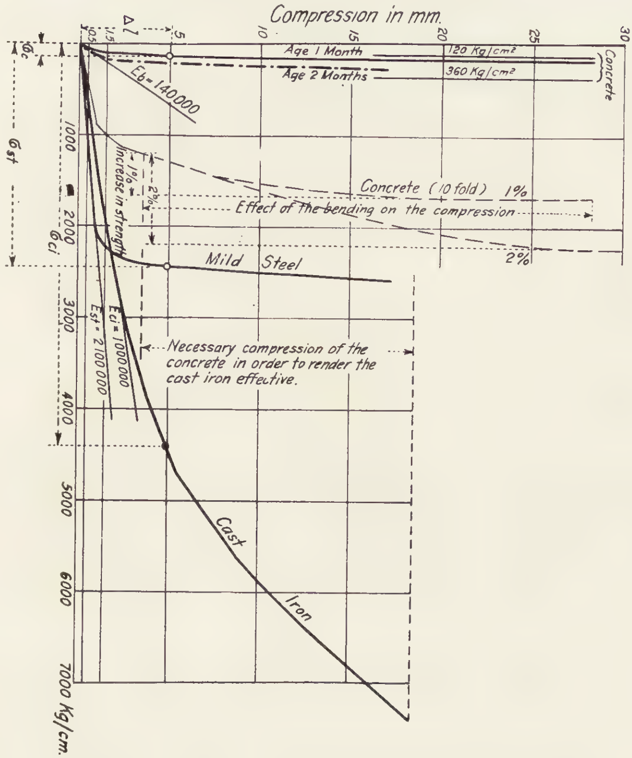


Fig. 3a. Curves of Change in Length of Concrete, Steel and Cast Iron.

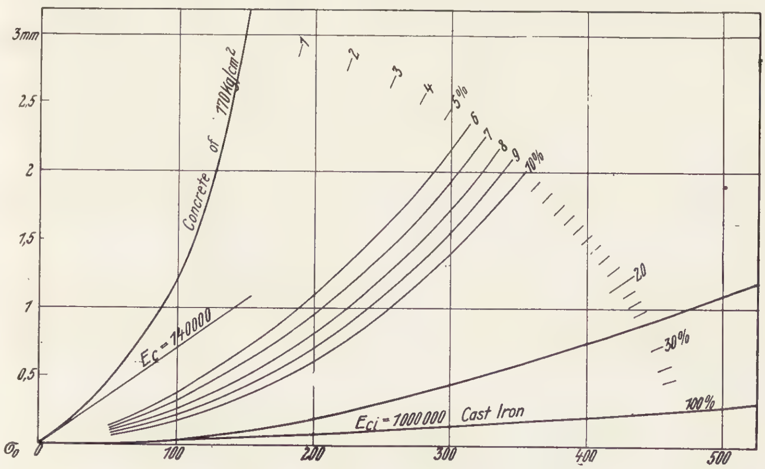


Fig. 3b. Curves of Change in Length Dependent Upon Amount of Cast Iron.

as useless in practice. An obvious proof of this has been furnished by piles made of hooped concrete.

For the proper utilization of steel reinforcement in concrete, it was necessary to gain a better knowledge of the coöperation of the two materials under pressure and to determine the strength obtained through such a combination. My report published in Pamphlet VIII of ''Forschungsarbeiten auf dem Gebiete des Eisenbetons'' indicated the manner of reaching this knowledge. In this report I have recorded parallel tests made in 1908, (1) with columns of steel alone and (2) those having an intermediate piece of concrete as in Figures 4a and 4b. These tests,* together with those of the next series in which steel columns alone and those with a concrete core were tested, proved conclusively that the ultimate strength of the concrete-steel column was the result obtained by adding the compressive strengths of the steel and of the concrete section. As I have shown, this result does not contradict the distribution of stress, which remains dependent upon the ratio of the coefficients of elasticity. With permissible loads, where no permanent changes in length occur, this may be taken at

$$n=\frac{E_{st}}{E_c}=\frac{30{,}000{,}000}{2{,}000{,}000}=15$$

This means that, with the necessarily equal changes in length in each material, if the concrete receives a stress of 600 lbs. per sq. in. (42.2 kg/cm^2), for example, the enclosed steel will have to carry $15 \times 600 = 9000$ lbs. per sq. in. (632.8 kg/cm^2).

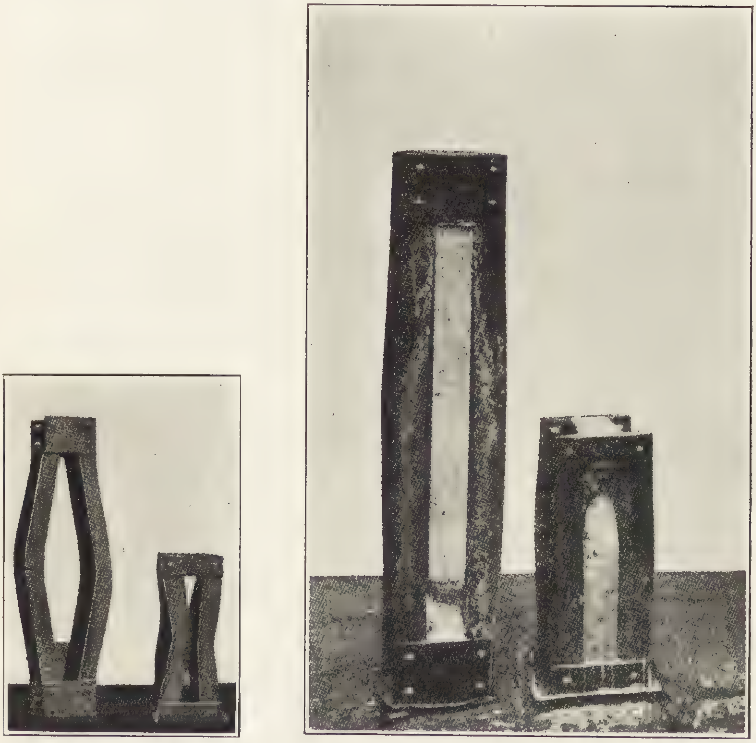
An explanation of these relations in the case of steel was difficult, because, as it happens, the ratio of the compressive strengths of both materials is the same, in that the ratio between the elastic limit and compressive strength can likewise be written

$$m=\frac{\sigma_{st}}{\sigma_c}=\frac{36{,}000}{2{,}400}=15$$

Thus the same value, $n=m=15$, has sufficed for both computations and proportions, in so far as one takes into account the average elasticity (2,000,000) and strength of concrete (2400

* Cf. for steel columns ''Beton u. Eisen'' 1907, p. 102 and 172. ''Welche statische Bedeutung hat die Einbetonierung einer Eisensäule''; also Beton u. Eisen, 1908, Nos. 96, 119, 148 and 193. ''Welcher querverband bedurf einer Eisensäule'', especially No. 149, part 6.

lbs. per sq. in. [168.7 kg/cm²] prismatic strength corresponds to about 3000 lbs. [210.9 kg/cm²] cubic strength). For this reason it is plain that tests on specially designed, highly reinforced members, like those in Figure 4, were required to prove the correctness of my theory for compressed members of concrete strengthened with steel.



Figs. 4a and 4b. Tests Showing Effect of Concrete Core Upon the Ultimate Strength of Steel Column.

In a strictly scientific manner, the trend of the addition of strength and its connection with the corresponding ratio of the elasticities may be demonstrated by three tests, with measurements of compression, where each material of the complex member is tested, first alone and then in combination. The compression curves so obtained make it possible to determine for any change in length Δl, the load necessary to compress a body of uniform

material by this amount. We need then only to see whether the same compression of the combined materials is caused by the sum of the loads of both taken singly. I have repeatedly tested this process,* and in order to quote another outside and competent authority, I will refer to the investigation† on this subject of Geheimrat Professor Rudellof, who has shown that there is a difference of 4% from the calculated sum. But since the properties of materials at the instant of rupture can never be determined with great exactness, this must serve as a convincing proof. We have only to free ourselves from the usual way of thinking, and we shall then find that the laws I have given on the summing up of the compressive strengths are just as self-evident, and at any rate better founded, than if we apply the ratio of the coefficients of elasticity, true for the initial stage, to the state of rupture, with its permanent changes in length, where it no longer applies. The only assumption to be borne out at the rupture point is that that material whose strength is first exhausted must show changes in length great enough to allow the other material to reach its point of fracture. These great changes in length take place in steel, as is well known, while it still retains the full strength of the elastic limit. We are therefore able, because of these phenomena, to add to the strength of the steel the high compressive strength of concrete. Now, when a third material, cast iron, is added, we need a concrete whose adaptability to compression up to the point where the cast iron becomes effective is assured. Ordinary reinforced concrete does not satisfactorily meet this requirement. We must therefore, for this and other reasons, make use of hooped concrete, with its great adaptability to compressive loads, and we are then in a position to assure the sum of the strengths of all three materials. Figure 3b shows the compression in a section which, at first containing only concrete, is then successively reinforced with cast iron in amounts varying from 1% to 100%.

I made use of the results thus obtained to get a solution for reinforced concrete which opens new fields for its use as compressive members in column construction or in the arch. This is expressed in the following equation:

* Beton und Eisen, 1908, p. 309, and 1913, p. 137.

† Part 21 of the "Berichte des D. A. f. E. B."

$$P = F_i \sigma_c \left(1 + \frac{F_c}{F_i}\right) + F_{st}\, 36{,}000 + F_{ci}\, \sigma_{ci} \quad . \quad . \quad . \quad . \quad (4)$$

When it is ascertained that the strength of the materials in combination is obtained by adding the compressive strength of the steel reinforcement to that of the concrete, we arrive at the obvious conclusion that the soft steel, exhausted already at the elastic limit (36,000 lbs. per sq. in. [2.530 kg/cm²]) is not sufficiently effective and that a material with high compressive strength, like cast iron, which is able to support at least three times the stress, or 100,000 lbs. per sq. in. (7030 kg/cm²), is the more suitable material. All the more is this the material best adapted to the purpose because its compressive strength can be raised to 150,000 lbs. per sq. in. (10,550 kg/cm²) without materially increasing the cost. It is now, therefore, a matter of taking such precautions as will insure the coöperation of two such different substances up to the point of fracture. It should be noted here, when referring to the above-mentioned drawings and publications,* that the brittle cast-iron within the hooping bands bends without breaking. A rupture does not occur until the loading is carried so far (that is, beyond the highest load) as to burst the hooping.

This investigation was undertaken with the aid of the Austrian A. f. E. B. (Committee on Reinforced Concrete) and I here refer to the publications dealing with the subject.† I will refrain also from an exhaustive treatment of the theoretical aspects of this subject and only state that the computation is based upon the actual results of the tests, and that the rupture stresses, introduced in the same way into this calculation as explained above for reinforced concrete, when divided by a factor of safety give the permissible stresses. Accordingly we get with

$$\sigma_c = \frac{2400}{4} = 600 : \sigma_{ci} = \frac{100{,}000}{4} = 25{,}000$$

$$m = \frac{100{,}000}{2{,}400} = 40 \text{ (round)}$$

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* Beton und Eisen, 1913, ''Neuere Bogen Brücken'', p. 62, part 62. (This core was shown in the Leipzig exposition.) Wochenschrift f.d. öffentl. Baudienst, 1915, pp. 163, 165, and table.

† Part 3 of the ''Berichte d Österr. A. f. E. B.'', by Director J. A. Spizer.

This value *m* for ordinary cast-iron is increased by using a better quality of cast-iron and notably decreased by the influence of buckling. Reference may be made here to a publication dealing with this subject for building columns.† Tests with bridge sections were carried out in 1912 in connection with the building of the ''Schwarzenbergbrücke'' in Leipzig, and a concluding publication on the construction of a bridge in Breslau by Herrn Dr. Trauer, chief bridge engineer of that city, is under way.‡

It must be emphasized at the outset that the use of hooped cast-iron with arch bridges brings about the concentration of forces in the individual ribs, and that as a matter of course, the use of a material of such high compressive strength can only be advisable where correspondingly great pressure justifies it. Accordingly, only bridges of long span or those intended for heavy loads present themselves here for consideration; that is those bridges which by reason of length of span or loading meet the special conditions justifying this type of construction. In all those cases in which the pressures can be sustained by an ordinary reinforced concrete section in suitable dimensions, no economic ground will justify deviating from the existing practice. Yet even in these cases, architectural considerations may decide in favor of a hooped bridge with cast-iron reinforcement. A comparison of Figures 5a and 5b will serve to illustrate this consideration of the exterior appearance. Figure 5a is a bridge of 22 meters (72.18 ft.) span, of ordinary reinforced concrete, crossing the Obra near Kosten. Figure 5b is a highway bridge of hooped cast-iron of 53 meters (173.88 ft.) span. The arch in the first case has about the same height as the parapet, while in the second bridge the span, 2½ times longer, needs only half as great a section for the arch. As is evident, these bridges have quite the appearance of iron arches and none of the clumsiness of concrete. In general, it can be said that with light bridges of 90 ft. (27.4 m.) span and under, architectural considerations may turn the decision in favor of hooped cast-iron, but only with arch bridges of great span or small rise of arch in proportion to span, does the cheapness of hooped cast-iron become significant. Shal-

† Wochenschrift f. ö B., Vienna, 1915, No. 11, by Obering. O. Schreier.

‡ ''Neuere Bogenbrücken aus umschnürten Gusseisen''; Berlin, 1913, W. Ernst and Son.

low arches especially, with their rapidly increasing horizontal thrust, can be carried out to advantage in hooped cast-iron in still shorter lengths of span.

Fig. 5a. Obra Bridge near Kosten. Ordinary Reinforced Concrete Bridge of 22 Meters Span.

Fig. 5b. Bridge Over the Main River Near Bamberg. Highway Bridge of Hooped Cast Iron of 53 Meters Span.

It is impossible to fix definite limits, if for no other reason than because a number of accompanying circumstances, aside from the mere cost of the arch, must be taken into consideration.

We will briefly mention these. Aside from the relative amounts of the contractors' bids, which often show enormous differences, we must consider that the contractor will figure with more than usual caution regarding a new and not yet sufficiently understood mode of construction, in order not to take undue risks, and further, that the patent fee, even though it be small, must also be included. The roadway will generally give rise to about the same cost if it is built in the same way. Nevertheless I have known instances where the entirely solid construction won the day, especially in competition with iron bridges with a wooden roadway. These cases are explained by the fact that although the solid construction is naturally, in itself, much more expensive, the remaining parts—girder and truss work and abutments—can be constructed much more cheaply and better than in the case of the light iron bridges. Three main items determine the cost of construction: the costs of the arch, the abutment and the falsework. The cost of the arch depends upon the amount of material in it. In relation to the determining load, it is not so simple, as for instance in the case of a column, where for a central load one can easily determine the section required. Here we have two extreme positions of the load and the question of temperature plays an important part. The great effect which temperature has upon concrete ribs to which the sun's rays have access has in most countries led to the almost exclusive use of the three-jointed arch. Only Hennebique of Paris advocates and uses the one-spanned arch even for great lengths of span. The difficulty encountered in the use of the full one-spanned arch consists herein, that the influence of temperature, however modestly estimated, increases with the increase in the strength of resistance of the arch. This leads therefore—just as in the field of long spans and heavy loads claimed for the hooped cast-iron—to impossibly clumsy proportions.

If, on the other hand, in a bridge of hooped cast-iron, we have determined the section able to carry the prospective loads with the necessary degree of safety; this must be done, as mentioned above, with the factor $m = 40$ (with allowance for buckling) in order to provide in this manner proper safety, with these loads, against rupture. It now only remains to point out that these stresses are not raised by the influence of temperature be-

yond the permissible limits. It must here be taken into consideration that variation of temperature can come into question only as an addition to the permissible stresses at the most with full load on the bridge (that is, with the permissible stress corresponding to this load), and that at these stress limits, the value $m = 40$, or a like number, is not correct, but rather a ratio of the coefficients of elasticity of 5 to 10 or say $m = 7.5$. Since the arch of hooped cast-iron has in the crown, just on account of its large amount of iron, a small moment of inertia compared with the abutment, it operates, as Engesser first pointed out, like a crown hinge, and thus reduces the influence of temperature to a minimum.

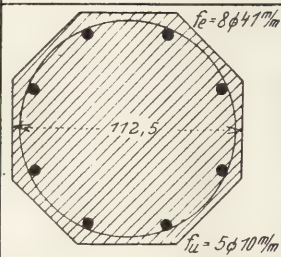
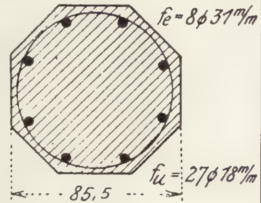
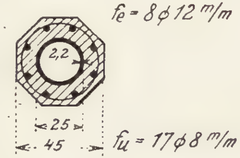
The above-mentioned engineer, Hennebique of Paris, known as the opponent of all joints in arch bridge construction, after some failures, took these conditions properly into account in his later structures, and in the great bridge of reinforced concrete over the Tiber at Rome, has perfected his method in the following way. He accomplished the reduction in the moments of inertia toward the crown by the construction of enormous sections at the abutment and in this way provided his arch with a weak crown-member that acts statically like a hinge joint. The cross walls of the arch were included in the section at the abutment. Without this arrangement and a corresponding construction of the crown, a reinforced-concrete arch of this span and load would, only with reference to the temperature stresses, be quite impracticable, and evidences of failure would be inevitable without the use of joints.

The use of joints weakens a structure, and if this does not affect the cost it is because the saving accomplished by doing away with effects due to temperature changes is greater than the loss thus incurred. Thus we see that the use of hooped cast-iron in the arch makes it possible, with the help of the full one-spanned arch, to overcome the structural limitations of reinforced concrete in respect to length of span. This limit of span length, obtained by a comparison of arches of medium proportion of rise to span in reinforced concrete hitherto constructed, is about 300 ft. (91.4 m.) and can be increased when the arch has a more nearly semicircular form. Between these two limits, where, on the one hand, we have small spans under 90 ft. (27.4 m.) in which the concrete

section suffices and reinforcement is a matter of only secondary importance, and, on the other hand, spans of over 300 ft. (91.4 m.) which can no longer be carried out even with the highest possible percent of steel in the concrete, may be found a whole series of stages with increasing economy for the arch construction, by the method with hooped cast-iron. An idea of the economic features can be gained only by the examination of a series of examples. Not to leave the matter entirely without foundation, a comparison may be introduced between centrally loaded columns of 300 tons total load (of the same safety) and of 3.5 m. (11.5 ft.) free length, wherein the choice of dimensions based on the German prescriptions is so made that the given columns have at least an ultimate strength of 1200 tons and thus an actual factor of safety of 4 or 5. This actual safety must not be confused with the calculated safety that is used in the calculation of the permissible stresses for concrete from the cubic strength. The actual safety often differs materially from these figures. By comparing columns of common reinforced concrete, of hooped reinforced concrete and of cast-iron reinforced concrete with reference to their respective costs per running meter, we obtain the following table of costs, based upon German prices. These figures will vary according to the price and quality of cast-iron and what loads local prescriptions consider permissible.

The abutments also are of great importance in connection with the total cost. If we compare arch bridges, in other respects alike, of which one has a heavy concrete arch and the other an arch of hooped cast-iron, the easier play of strains in the second case gives, as a general thing, an opportunity to improve the abutments, either as to economy or safety of construction. The more difficult the construction of the foundation, the more clearly is this demonstrated, and it holds also for the often occurring case when it is necessary to substitute for two or more spans a single arch of hooped cast-iron. While it is possible under such favorable conditions to lower the costs by one-half, it usually causes surprise that in the case of small arches and rock abutments there is so little difference that this is lost sight of in the variation of the bids. A better understanding of the facts would make the explanation self-evident.

The cost of falsework is the most important item of expense.

Load	300 t.			300 t.			300 t.		
Cross Section									
	Weight	Price Mk.		Weight	Price Mk.		Weight	Price Mk.	
		Unit	Amt.		Unit	Amt.		Unit	Amt.
Concrete	1.050	32.0	33.50	0.600	32.0	19.20	0.1185	34.0	4.02
Longitudinal Reinforcement	89.2	0.21	18.80	51.00	0.21	10.70	8.10	0.21	1.70
Bands or Hoops	13.4	0.24	3.21	154.00	0.24	37.00	8.55	0.24	2.05
Outer Shell	3 75	2.50	9.38	2.85	2.50	7 11	1.50	3.00	4.50
Cast Iron							125.0	0.25	31.20
Royalty				154.0@0.03		4.61	125@0.1-2.5		10.00
Sums or Totals		Mk.	64.89		Mk.	78.62		Mk.	53.47

Economic Comparison of Different Types of Reinforcement.

This is determined for stone bridges by the weight of the single blocks and for concrete bridges by the weight of the unset concrete mass. Here, however, we have only to construct a falsework for mounting the cast-iron parts. The concreting of the latter requires so slight an additional weight that it need not be taken into account in the dimensions of the falsework. Without going farther into the details of a comparison for wood (see Fig. 11) I

Fig. 6. Portable Iron Falsework in Course of Construction.

will here give a construction in steel as it has been repeatedly applied by the firm "Ellmer and Company" in Stettin. This consists of pillars of steel section, secured together with screw fastenings, which can be adjusted to the required height and which by means of beams run through, furnish support for both arch ribs. (Fig. 6.)

With the help of wedges, the trough-shaped form of the ribs is placed on the falsework. The latter serves as a platform for arranging the stirrups and cast-iron ribs and for handling the concrete which is poured in in a soft state. If, according to the general custom, some time is allowed to elapse after concreting the arch, the concrete will furnish, even with the small compressive strength of 600 lbs. per sq. in. (42.2 kg/cm^2) a rib of sufficiently great carrying power to sustain the load of the whole structure. The strength of the falsework is no longer of impor-

tance. The iron falsework can be used again repeatedly, and in this way the cost of its construction is no more than the amortisation or a rental charge, while the value of wood falsework after having been once used is very small. In this case it is even possible to make use of the wood members in the next piece of work with but little waste, so that the cost of falsework to a firm equipped for such work can be reduced to a minimum. Since the cost of the falsework in arch bridge construction may amount to half the total expense, and has, where long spans were necessary, made the construction economically impossible, the economic importance of the proposals here offered, even from this item alone, is evident without further proof. Since there is here no space for an estimate of costs, I intend to publish such a calculation—together with examples and a comparison of the costs incurred in different systems of arch construction—in one of the early numbers of ''Beton und Eisen''.

We shall now proceed to describe some examples of bridges, grouped under the most important types which come into question. We distinguish according to the construction:

I Arches with roadway above.
II Arches with suspended roadway.
III Arches with tie-rods.

I. ARCHES WITH ROADWAY ABOVE.

The arch with roadway above is the commonest form and is distinguished from the usual arch bridge only in the cross sectional form of the ribs on which the columns rest.

The first bridge of this type is the Schwarzenbergbrücke on the grounds of the International Building Exposition at Leipzig, 1913. This structure received the medal of the Kingdom of Saxony and after the close of the Exposition was taken over by the city of Leipzig as a permanent monument, although it had been built for only the cost of a temporary bridge.* The only bridge of this kind built during the following winter (1913) was near Depp on the Baltic coast† The arch, almost at the point of

* ''Neuere Bogenbrücken'', with many plans of the Schwarzenberg bridge; Berlin, 1913, W. Ernst and Son.

† Stahl und Eisen, 1913, No. 48, part 23.

completion, was still lying in the falsework when it was destroyed by the great storm flood of Dec. 24, 1913. The water, hemmed in by the falsework, opened for itself a course behind an abutment and finally overturned bridge and falsework. All the remaining structures that are to be described here belong to the season of 1914, and therefore on account of the war most of them have not progressed beyond the drawing up of the project. The construction has been postponed until after the restoration of peace.

Among the remaining bridges of this type should be mentioned a two-jointed arch for a railroad bridge over the Persante

Fig. 7. Bridge of Fig. 6 After Concrete Forms Were Removed.

River near Körlin, of 45 meters (147.64 ft.) length of span. Figure 6 shows the bridge in the falsework; Figure 7 shows it completed. Figure 8 shows longtitudinal and cross sections and ground plan. It is a two-hinged arch with concrete joints and was executed by Ellmer and Company in Stettin.

Among the projected structures whose execution has been postponed by the war is a bridge of 52 meters (170.6 ft.) span to be built over the Kanker River near Krainburg under commis-

Fig. 9. Bridge Over the Elbe at Dresden; Span of Center Arch 140 Meters.

sion of the Imperial Royal Ministry for Public Work in Austria; further, a bridge of 70 meters (229.66 ft.) span to be built over the Spree between Neukölln and Treptow; and finally, a project for a bridge over the Elbe at Dresden for which the present writer, with the firm Holzmann and Company, has made the plans, commissioned by the City Council of Dresden. (Figure 9) The last named project claims attention, not only because of its span of 140 meters (459.3 ft.), but especially for the ratio of

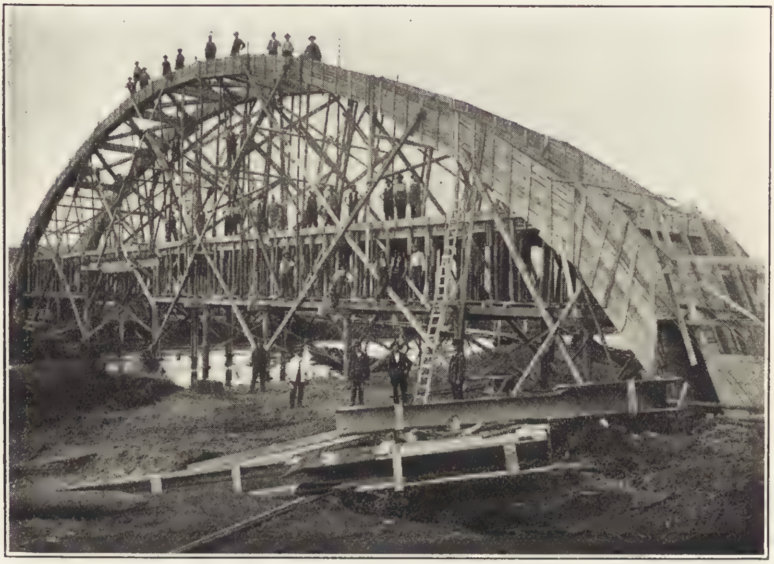


Fig. 11. Bridge Over Main River near Bamberg during Course of Construction.

rise to span of arch (1/13), a value characterizing no other similar massive bridge among those previously constructed.

II. ARCH WITH SUSPENDED ROADWAY.

The difficulty in the use of arches under the roadway is generally caused by the fact that the available structural height is too small for the arch. These proportions are entirely changed when it is possible to place the crown 18 to 20 feet (5.5 to 6.1 m.) above the roadway center. The bridge dimensions thus made possible, with the comparatively high rise of arch, result in a favorable design of abutments and therefore an economical bridge.

The first construction of this kind was undertaken, likewise, in the year 1913 by the firm of Hauch and Company, in Coburg. It is a bridge with a span of 55 meters (180.45 ft.) over the Main River near Bamberg (Unter-Leiterbach) (Fig. 5b). The principal dimensions of the structure are given in Fig. 10, while Fig. 11 shows the bridge in the course of construction. The falsework shows the heavy proportions that seem unavoidable in structures of solid reinforced concrete. Figure 12 shows the

Fig. 12. Bridge Over Main River near Bamberg before Removal of Falsework.

bridge before the removal of the falsework. On account of lack of space I will not give the items of cost for its construction. Figure 13 shows details of the reinforcement of the arch. Of the great number of similar outstanding projects, may be mentioned a standard bridge of 42 m. (137.79 ft.) span to be built over the Oder-Vistula canal in Galicia, by order of the Imperial Royal Board of Water-supply; the bridge over the Mür near Stübing of 52.6 meters (172.8 ft.) span; and lastly, a bridge for the city of Breslau. In the latter case it is intended to suspend an extremely heavily loaded bridge of 15.5 meters (50.85 ft.) width on two arches of 54 meters (177.16 ft.) span without the use of cross- or wind-bracing. In spite of the war, which renders the

investigation of new scientific questions difficult, the Council of the City of Breslau, at its own cost, has instituted extended investigations to determine the most advantageous form for this arch, and these test pieces, which have already been concreted, will be taken to the laboratories in Dresden and Berlin during 1915.

Finally, I will mention a number of bridges in countries which I may designate as hostile, and for which plans have been made, but, on account of the war, not yet executed. For example there is the bridge (Figure 14) over the Baltic railway station in Petrograd, the construction of which is in the hands of Herr Ing. Koludczki in Wilna. An interesting feature of this structure is the execution of "pendulum" piers in reinforced concrete. According to the last news received by way of Switzerland, the construction has already begun. The typical arrangement of the cast-iron reinforcement is shown in Figure 15.

III. ARCHES WITH TIE-RODS.

In so far as the arch cannot be carried down to the abutment because the latter can receive only vertical forces, the span is constructed as a two-jointed arch with tie. The cost of these tie-rods is considerable and they are to be avoided where possible. Only where the cost of construction of abutment is very great can their use be considered economically advantageous. The same is true where old abutments must be used, or where on account of adjoining buildings there is no room to build abutments. The length of span is limited in this type of bridge by various constructional details, of which I will mention only one: The stretching of the tie-rod results not only in additional tensions but also in a dipping at the center, which must be allowed for in this construction by extra height. It is advisable not to attempt too long spans in the first structures of this type, but rather to advance step by step in this new field until more practical experience is gained. In spite of the difficulties mentioned, its use has constructive and economic possibilities such as no other material can offer. In making this statement I have in mind a competition instigated by the Halle Board of Railroad Directors (Prussian State Railroad) in order to secure under extremely difficult conditions a solution suited to the purpose. The competition was

rendered particularly hard for reinforced concrete, because it was necessary to meet the requirements imposed by Herrn Geheimrat Labes of the Berlin Railway Board. In spite of that, steel did not come economically into consideration; while among the plans for the use of reinforced concrete, the one about to be described was chosen for execution. Figures 16a and 16b show the most important details of the structure for present consideration. Figure 17 shows the structure before concreting; Figure 18 the tie-rod mounted on a laying-out floor and the near-by cast-iron

Fig. 17. Bridge of Fig. 16a before Concreting.

reinforcement. In Figure 19a is shown the interior view of an arch-rib before concreting. The stirrups are mounted as shown in the accompanying drawing (Figure 20) and thereupon tie-rod and compression reinforcement are placed. Next the introduction of the soft concrete into the core is carried out with great celerity, suffering a short delay only by the closing of the stirrups. Figure 21 shows the progress of construction at the time of sending this report—the end of April.

In connection with the bridge types described in subdivisions II and III, I will call attention to another combination to be ap-

plied in the execution of several projects which furnishes a means of avoiding (in part) the use of the expensive tie-rod. It is suited to a construction with two or three spans. If we first consider two spans, there results an equal loading of each and an equally great horizontal thrust over the central pier. I utilize the force of this horizontal thrust in order to determine the dimensions of both end abutments. Next I seek to find the maximum thrust on the middle abutment, which occurs when one span is entirely empty and the other loaded to full capacity. The next arch must

Fig. 18. Tie Rods Mounted on Laying-out Floor. Bridge of Fig. 16a.

be able to receive this horizontal thrust of the useful load, and its roadway must accordingly be built to act as a strut.

The same principle is applied to three spans, where two pillars capable of small movements (which may be termed "pendulum" piers) are placed, and corresponding to these, two such struts and end abutments. It is possible, in the case of different lengths of span, to produce an equalizing effect in the larger arch by the use of a weak tie-rod.

Even though I believe that, in the foregoing, I have described the most important types of bridges of this kind, it is neverthe-

Fig. 19. Interior View of Arch Rib before Concreting.

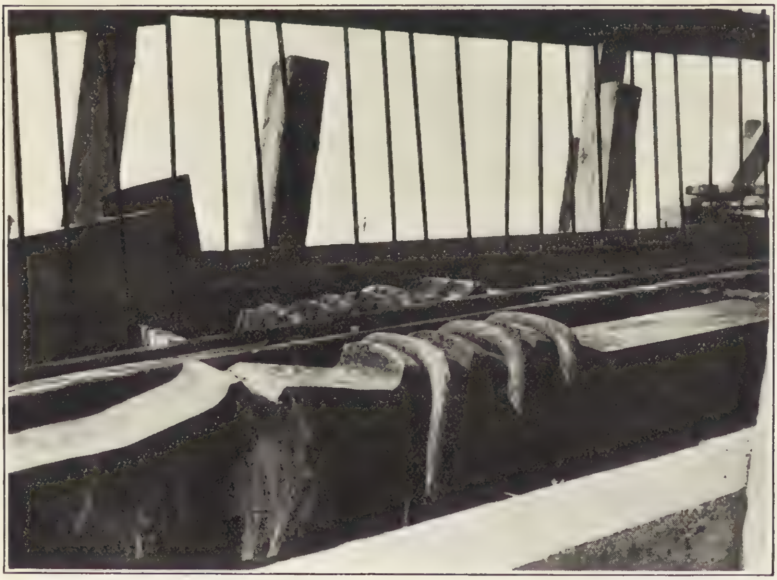


Fig. 19b. Fastening of Verticals on Arch Rib.

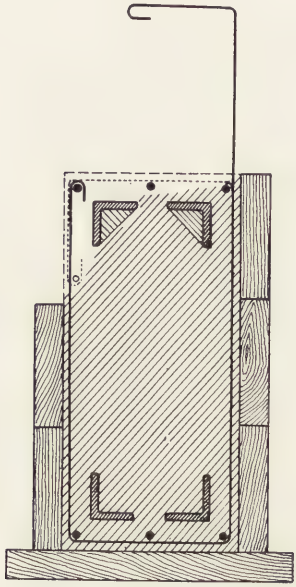


Fig. 20. Mounting of Stirrups.

Fig. 21. Bridge of Fig. 16a Nearly Completed.

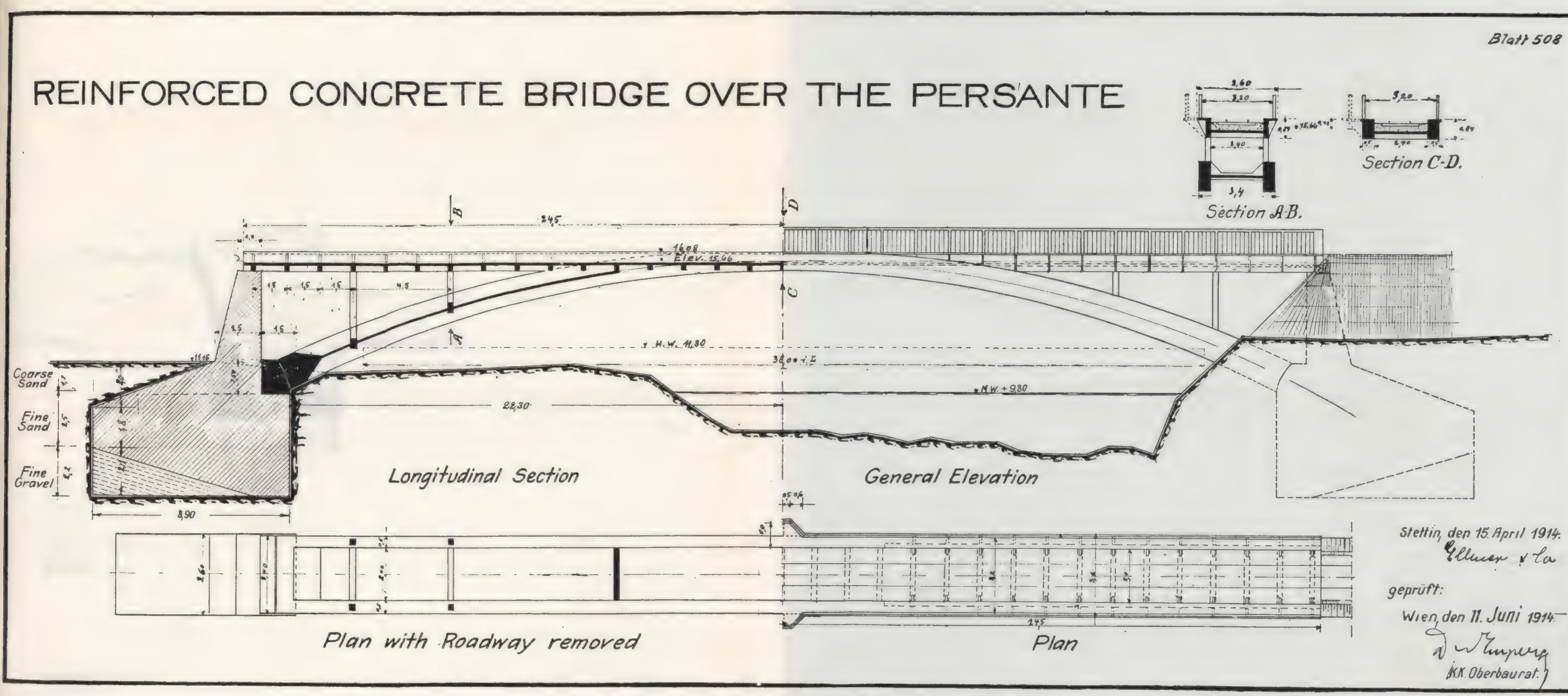


Fig. 8. Plans for Bridge Over Persante River near Korlin.

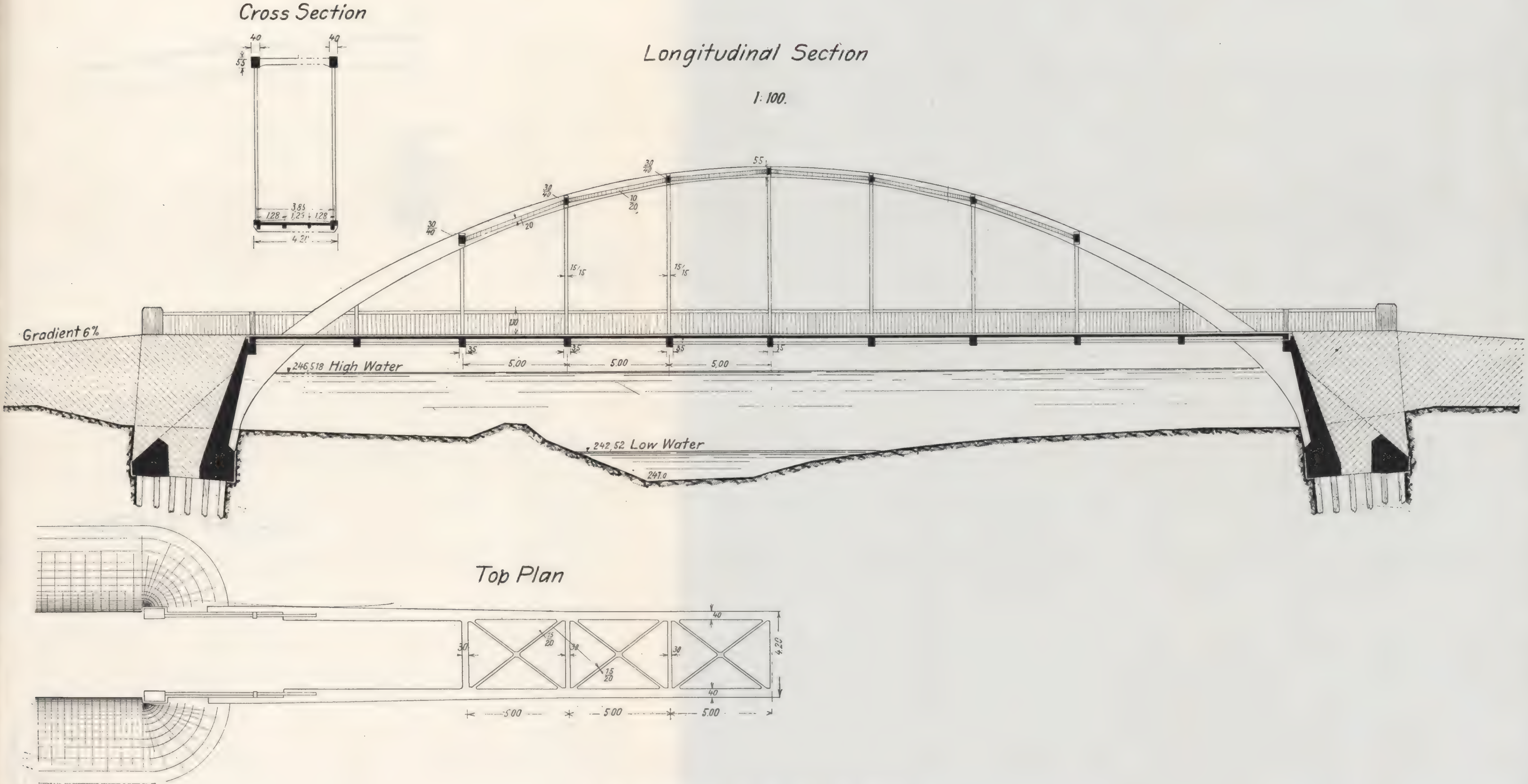
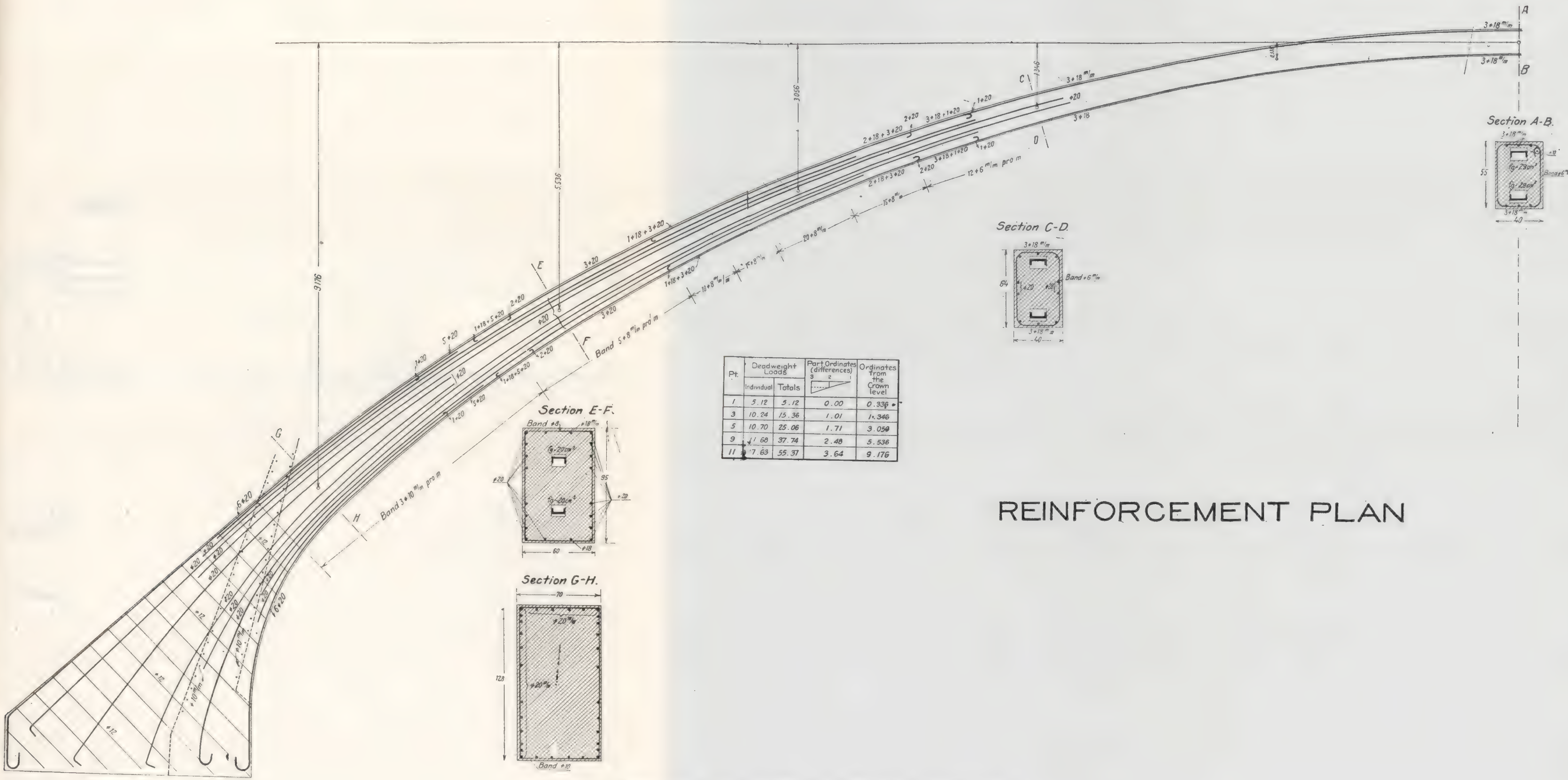


Fig. 10. Bridge Over the Main River Near Bamberg.



Pt.	Deadweight Loads		Part Ordinates (differences)	Ordinates from the Crown level
	Individual	Totals		
1	5.12	5.12	0.00	0.336
3	10.24	15.36	1.01	1.346
5	10.70	25.06	1.71	3.050
9	11.68	37.74	2.48	5.536
11	17.63	55.37	3.64	9.176

Fig. 13. Reinforcement Details for Bridge Over Main River Near Bamberg.

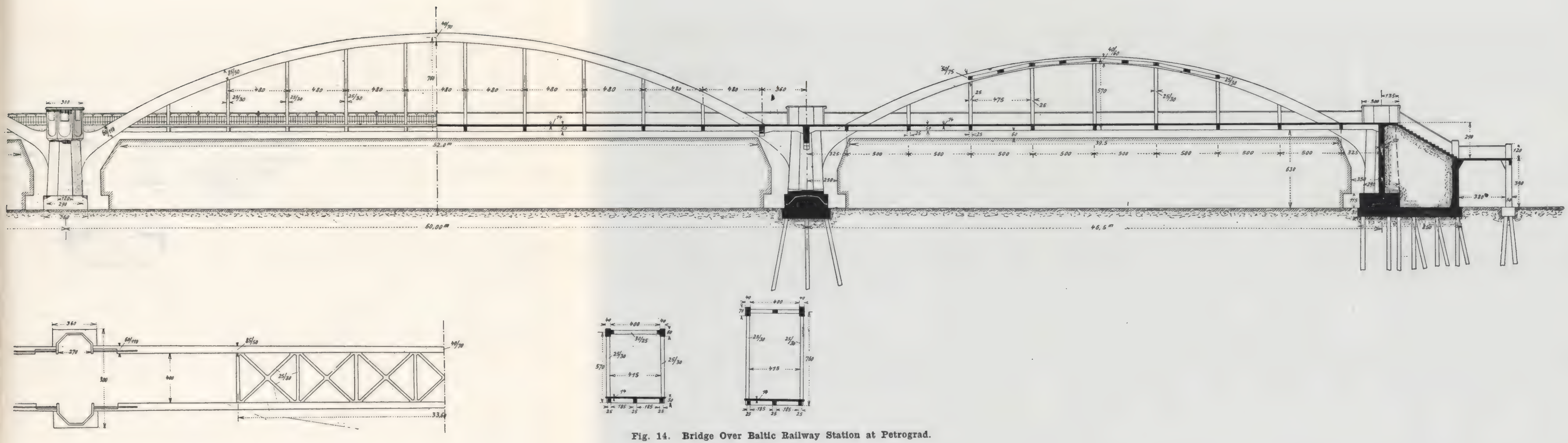


Fig. 14. Bridge Over Baltic Railway Station at Petrograd.

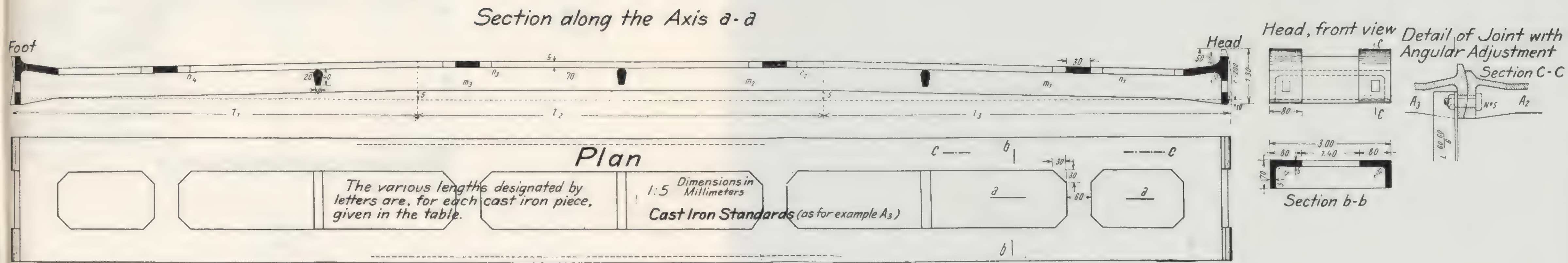


Fig. 15. Cast Iron Reinforcement for Bridge of Fig. 14.

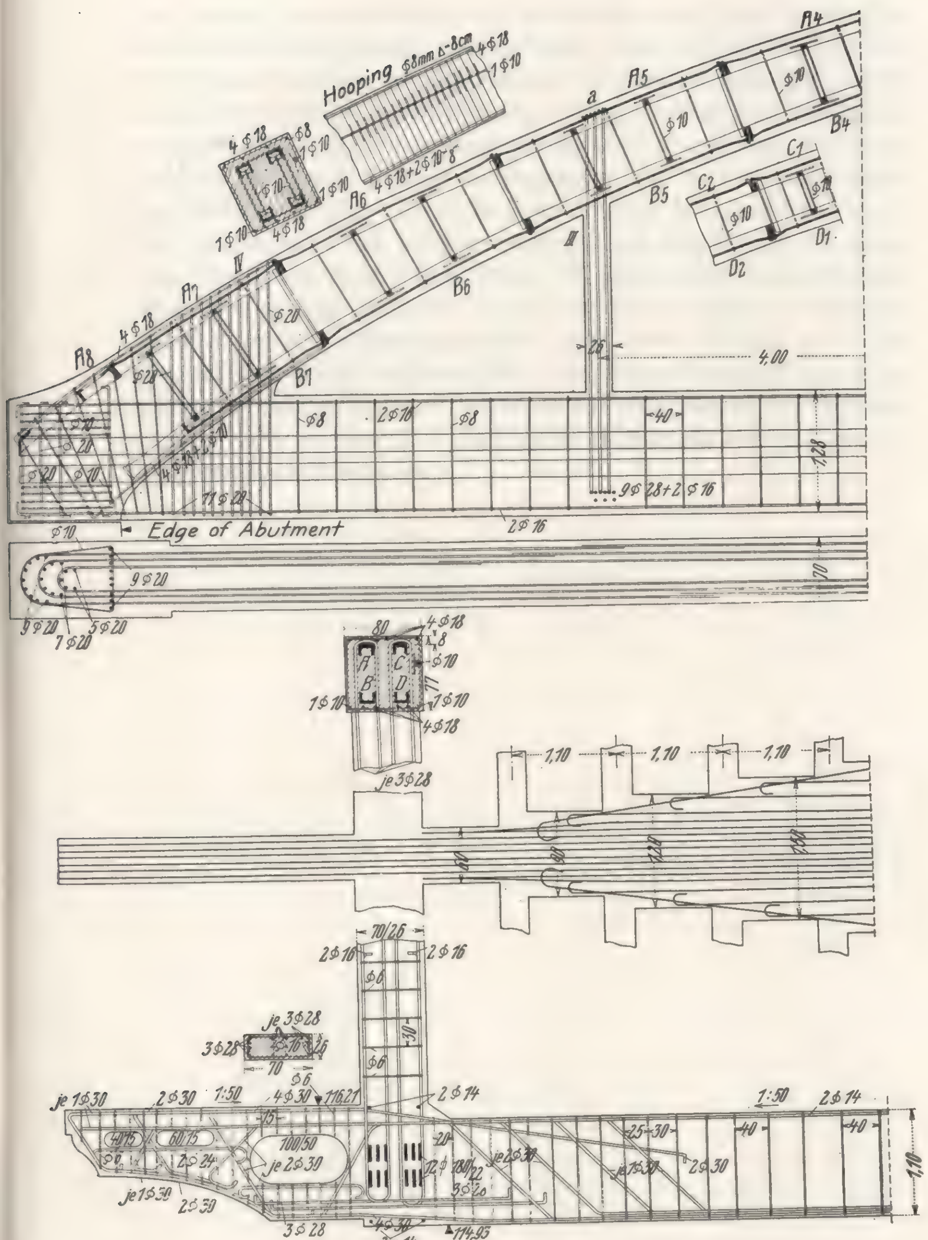


Fig. 16a. Plans for Bridge in Halle.

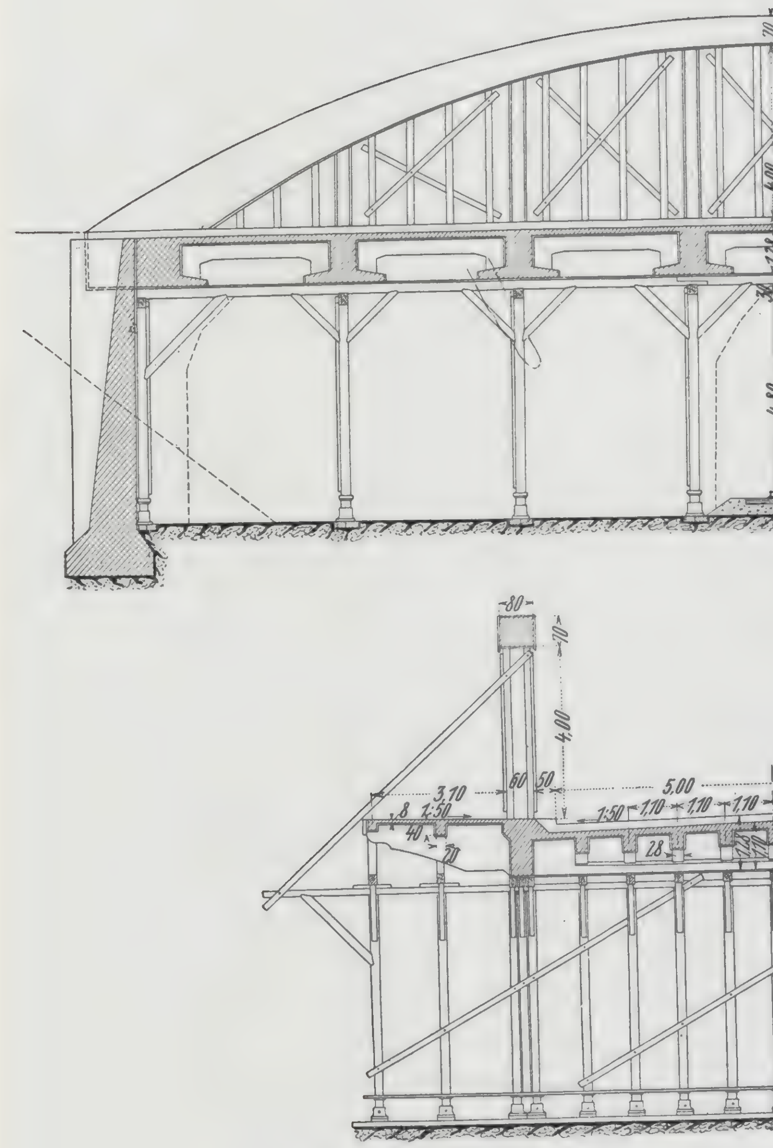


Fig. 16b. Plans for Bridge in Halle.

less evident that with these beginnings the field of application is by no means exhausted. Accordingly, the description of these structures is mainly for the purpose of exemplifying these methods of construction and of giving to my professional colleagues an opportunity of taking them perchance into careful consideration with a view to further development. To me the most important content of this report is that through the introduction of this intermediate link between concrete and steel bridge construction, the limits of the application of solid monumental bridges have been greatly extended, at the cost of the territory formerly claimed for the bridges executed in steel alone. From now on the professional bridge engineer who, in a case like that just mentioned, would have turned to steel as the only material to be taken into account, is now in a position to undertake designs in concrete for such structures.

Paper No. 69

PUBLIC UTILITIES.

By

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The topics suggested for discussion in the Section on Municipal Engineering are:

(1) City Planning.
(2) Streets.
(3) City Drainage and Disposal of Waste.
(4) Water Supply.
(5) Protection against Fire.
(6) Transportation Problems of Cities.
(7) Utilities.
(8) Rural Highways.

The single topic Utilities alone covers so much and involves so many vital questions that it is impossible within the limits of this paper to consider any one of these questions exhaustively.

It has been suggested that I should consider the questions involved in the municipal ownership of the public utilities as compared with their private ownership. This alone would carry me far beyond the proper limits of this paper.

On the part of the public there is a notable lack of information and much misinformation on the subject of municipal control of public utilities. This has had its root, perhaps, in abuses practiced by certain of the privately-owned public utilities, abuses more than paralleled by those practiced against practically all of these undertakings by venal legislators and their unscrupulous allies.

It is to be noted, under this division of the proposed study, that the topics (1), (2), (3), (5), and (8) at once suggest municipal ownership and operation. These branches of municipal administration do not involve selling service to certain only of the inhabitants, but the providing of facilities to and doing certain things for the convenience, comfort, and safety of all of the inhabitants. While no doubt the work of construction for these several departments could be done more economically and efficiently through contracts with private organizations, the operation of these departments does not naturally present the opportunity for selling the service thus provided. It might be argued that at least some cities could contract advantageously to have these services performed for the people as a whole; but let that be as it may, the questions involved as between the municipality performing these duties through its own officials or through a contracting agent are essentially different from the questions involved in connection with Transportation (topic 6) and Utilities (topic 7).

In this connection Transportation can be considered as one of the public utilities. The utilities sell their service to those who wish to buy and pay therefor by unit rates; whereas, the city must be planned; the streets and highways must be made, paved, and maintained; the city must be drained and sewered; and must be protected from fire—and all for the benefit of the inhabitants as a whole and apart from their individual tastes or desires. In connection with this constant service there is no opportunity for personal trading between the agency rendering the service and those who are served. If this class of service were provided for the people by contract with the municipality, there would be great difficulty in arriving at a basis for the compensation of the contractor which would be fair to both parties. This is particularly apparent in connection with protection against fire.

These several classes of municipal administration, therefore, more naturally fall to the elected and appointed representatives of the citizens to do for them as a whole. On the other hand this involves the waste and lack of efficiency which necessarily, it would seem, attaches to municipal administration—and particularly in a republican government—through

the far-reaching and insidious influence of politics, this being part of the price we pay for manhood suffrage and the personal liberty which we hope thus to secure.

Water Supply (topic 4) stands in between these activities and Utilities. Water is needed and must be used for all the inhabitants, and it is not safe to leave it to the individual to say how much or how little he shall use or shall be used on his account. The city would have to purchase much for itself for fire and other purposes. On the other hand, water can be sold as a commodity. Water has been furnished more economically and most satisfactorily by contractors, but the practice is now generally established of keeping this department in the hands of the municipality. There is, however, no doubt that the cities of the United States are paying for their water supply far more than is necessary, and this by reason of the apparently unpreventable injection of politics into the administration. There are many sources of waste of a financial nature in addition to the actual leakage of water from the mains, service pipes, and fixtures. In the United States this leakage of water runs up to figures which it is difficult for the layman to accept. A study of some of the special investigations of water leakage is particularly recommended to municipal engineers.

But when we come to the Utilities—gas, electric, and transit systems—we come to trading, the selling of service to those who wish to buy and in such measure as they individually determine. Here at once is presented an opportunity for private enterprise, for a basis for compensation fair to both parties can be found. The operation of these utilities as regulated monopolies offers the opportunity for avoiding much of the waste due to politics, an opportunity which the private agencies who undertake these enterprises are not permitted to enjoy to the limit.

The service offered by these utilities is not for all alike but only for those who ask for it and are willing to pay for it. The cost, therefore, being capable of apportionment to those benefited, should not in any measure be laid upon those not directly benefited. With those who are honest and open-minded, and who have had even a limited experience with the

politics of municipal administration, it seems hard to understand how arguments can be found to convince them of the comparative advantages of municipal ownership and control of public utilities.

It is not necessary to bring in charges of dishonesty and fraud to support the statement that politics in our country necessarily influence injuriously the administration of the municipality's revenues. Nor need this be considered necessarily as reflecting on the officials in charge, for they are not free to do their best to secure efficiency and economy. As this is true generally of the departments of the Federal Government, it certainly is true of the State and Municipal Governments.

If we turn from theorizing to practice, we can refer to the records of the municipalities which have owned and operated their public utilities.

The case of Philadelphia under its Gas Trust is, we hope, a case by itself. Here we need not mince words, for we can say that this was a case of all kinds of graft and politics at their worst.

But there are many other examples to be found in the records which show to disadvantage by comparison with privately-owned and operated utilities.

This question was taken up for investigation by the National Civic Federation in 1905. The intention was to make the investigation exhaustive and the report thereon conclusive. The effort was made to have all interests and all points of view represented on the Committees to whom this work was assigned. It was hoped that this would lead to a definite conclusion. But even after the gathering of data, the differences of opinion were found to be irreconcilable, and the report was the result of a compromise. As far as the final report is concerned, many questions were left unanswered; but a careful study of all the accompanying documents fails, in my opinion, to provide any justification for municipal ownership and control in this country.

This work was undertaken by the National Civic Federation Commission on Public Ownership and Operation in pursuance of a resolution adopted October 5th, 1905.

The general conclusions and reports were published in

1907 in three volumes, under the title "Municipal and Private Operation of Public Utilities". Notwithstanding the defects already referred to, these volumes are of great value in connection with the study of this subject. I, therefore, feel warranted in making an extended reference to this record.

The details of the investigation and report were entrusted to a number of Committees and Sub-Committees and selected experts.

The Executive Committee was composed of twenty-four members representing, through their highest officials, railroads and other corporations, labor unions, colleges and universities, national banks; and also private bankers, editors, lawyers, and merchants.

The Committee on Investigation was composed of twenty-one members. This Committee was also representative of the interests already named.

There was an Executive Sub-Committee on Plan and Scope composed as follows:

Professor Frank J. Goodnow, now President of Johns Hopkins University.

Mr. J. W. Sullivan, Editor, Clothing Trades Bulletin.

Professor Edward W. Bemis, then Superintendent of the Cleveland Water Works.

Mr. Milo R. Maltbie, then member of the New York Public Service Commission, First District.

Mr. Walton Clark, then Third (now Second) Vice-President, United Gas Improvement Company.

There was a Sub-Committee on Final Conclusions, as follows:

Mr. Melville E. Ingalls, Chairman, Board of Directors, "Big Four" R. R.

Dr. Albert Shaw, Editor, Review of Reviews.

Mr. E. A. Moffett, Editor, Bricklayer and Mason.

And finally a Sub-Committee on Summation of Evidence, as follows:

Professor Edward W. Bemis.

Mr. Walton Clark.

Professor Frank Parsons.

Mr. Chas. L. Edgar.

Mr. Maltbie acted for Professor Bemis during the latter's illness, and Mr. Sullivan acted for Mr. Edgar during his absence.

The actual work of investigation, at home and abroad, was assigned to members of the several Committees and to selected experts.

In the work abroad the co-operation was secured of experts and prominent advocates and opponents of municipal ownership.

The investigation was begun in March 1906 and was practically completed in May 1907. A few weeks later the Majority Report was completed and signed by nineteen of the twenty-one members, two of the nineteen attaching a memorandum of dissent on certain points. Mr. Walton Clark, somewhat later, submitted a Minority Report.

The Introduction as found in Volume 1 states—"Taken in the aggregate, this published matter represents a full two years of labor, and the expenditure of considerable money." The Majority Report first points out the difficulties found in the way of a fair comparison between the results found in the places selected for examination in the United States and the greater or varying difficulties when comparing with the results from plants abroad.

In connection with the comparison between the United States and Great Britain the report contains these words:

> "In other words, a measure of success in the municipal management of public utilities in England should not be regarded as necessarily indicating that the municipal management of the same utilities in this country would be followed by a like measure of success."

The report compares the municipal governments of the United States most unfavorably with the like institutions of Great Britain. It is further emphasized that the conditions found in such cities as Glasgow, Manchester, Birmingham, and others "are distinctly favorable to municipal operation."

The report states:

> "Our investigations teach us that no municipal operation is likely to be highly successful that does not provide for:

> First—An Executive Manager with full responsibility holding his position during good behavior.
>
> Second—Exclusion of political influence and personal favoritism from the management of the undertaking.
>
> Third—Separation of the finances of the undertaking from those of the rest of the city.
>
> Fourth—Exemption from the debt limit of the necessary bond issues for revenue-producing utilities, which shall be a first charge upon the property and revenues of such undertakings.''

The report warns against ''the danger here in the United States of turning over these public utilities to the present government of some of the cities.''

The report thus sums up ''some of the more important'' of its conclusions:

> ''First—Public utilities, whether in public or private hands, are best conducted under a system of legalized and regulated monopoly.
>
> Second—Public utilities in which the sanitary motive largely enters should be operated by the public.
>
> Third—The success of municipal operation of public utilities depends upon the existence in the city of a high capacity for municipal government.
>
> Fourth—Franchise grants to private corporations should be terminable after a fixed period and meanwhile subject to purchase at a fair value.
>
> Fifth—Municipalities should have power to enter the field of municipal ownership upon a popular vote under reasonable regulation.
>
> Sixth—Private companies operating public utilities should be subject to public regulation and examination under a system of uniform records and accounts and of full publicity.
>
> Seventh—The Committee takes no position on the question of the general expediency of either private or public ownership. The question must be solved by each municipality in the light of local condi-

> tions. What may be possible in one locality may not be in another. In some cities the companies may so serve the public as to create no dissatisfaction and nothing might be gained by experimenting with municipal ownership. Again, the government of one city may be good and capable of taking charge of these public utilities, while in another it may be the reverse. In either case the people must remember that it requires a large class of able men as city officials to look after these matters. They must also remember that municipal ownership will create a large class of employees who may have more or less political influence.''

The last sentence is notable for its naïveté.

These conclusions reflect in some degree the indecisiveness which is more in evidence in the body of the report. When the names of the nineteen men who signed the report are read, we may well believe that it was no small undertaking to bring them into accord even to the extent found. As it was, Charles L. Edgar and W. J. Clark, although they signed the Majority Report, filed the following ''Dissent as to Particulars'':

> ''We, the undersigned, dissent from the Report of the Investigating Committee, as follows:
>
> 1st.—The Report says:
>
> 'We have come to the conclusion that municipal ownership of public utilities should not be extended to revenue-producing industries which do not involve the public health, the public safety, public transportation, or the permanent occupation of public streets or grounds, and that municipal operation should not be solely for profit.'
>
> This sentence is so drawn that to a casual reader it implies that the opposite is advisable. From this we strongly dissent.
>
> 2d.—The Report says:
>
> 'To carry out these recommendations effectively and to protect the rights of the people, we recommend that the various states should give to their municipal-

ities the authority, upon popular vote, under reasonable regulations,' etc.

The words 'under reasonable regulations' were put into the Report at the suggestion of Charles L. Edgar, and were intended by him to mean such regulations as would compel deliberate consideration not only by the people but by their representatives, and would consequently prevent the superficial attractiveness of the scheme from over-riding the second sober thought of the people. We strongly dissent from any definition of 'regulations' which does not cover these points.

3d.—The second and fifth conclusions in the latter part of the Report, being merely repetitions of previous statements, are, of course, subject to the same dissents."

As before stated, a Minority Report was made by Mr. Walton Clark, President of the Franklin Institute and Vice-President of the United Gas Improvement Company, a man of wide experience, open mind, and judicial temperament. This Minority Report is in marked contrast with the Majority Report because of its definiteness. It is proper in this connection to state that Mr. Walton Clark, as a member of the Executive Sub-Committee on Plan and Scope and also of the Sub-Committee on Summation of Evidence, was active in the details of the investigation from first to last. An opportunity to judge Mr. Clark's work is found in the reading of the paper written by himself, and Charles L. Edgar, President of the Edison Electric Illuminating Co., of Boston, entitled "Analysis and Interpretation of the Information concerning the Municipal Ownership of Public Utilities collected by the Investigators of the National Civic Federation." This is to be found on page 303, Volume 1.

Mr. Clark's Minority Report is based upon his own investigations, here and abroad, and the analysis of all the information collected by the other investigators.

Because of these facts I quote this Minority Report in full:

MINORITY REPORT.

To the Commission on Public Ownership
of the National Civic Federation:

Gentlemen:—

I have the honor to submit the following report of the minority of the Committee on Investigation, appointed by you under a resolution as follows:

> RESOLVED, That Melville E. Ingalls, Talcott Williams, W. D. Mahon, Frank J. Goodnow, Walton Clark, Dr. Albert Shaw, Edward W. Bemis, John H. Gray, Walter L. Fisher, Timothy Healy, William J. Clark, H. B. F. MacFarland, Daniel J. Keefe, Frank Parsons, John R. Commons, J. W. Sullivan, Leo S. Rowe, F. J. McNulty, Albert E. Winchester, Charles L. Edgar, Milo R. Maltbie, be appointed a Committee of Twenty-one to investigate in this country and in Europe the advisability of private and municipal ownership affecting gas, water, electric power and light, and street railways, and that this Committee of Twenty-one be empowered to fill vacancies or add to their number, subject to the approval of the Chair.

I regret that my understanding of your charge to the Committee of Twenty-one, to investigate and report to you, as per the above resolution, leads me to the necessity of presenting a minority report.

I agree with my associates on the importance of directing your attention to the dangers and difficulties attending municipal ownership. I do not dissent from their conclusion that companies entrusted with franchises and charters for the operation of so-called public service industries should be subject to regulation. I write a minority report because, if I correctly understand your instructions to your investigating Committee, the majority report does not, in its form and scope, answer your reasonable expectation; and because I am not able to agree with what I understand to be the meaning of some few of the statements made therein.

Recognizing the almost supreme importance of an adequate and cheap supply of pure water, I dissent from one of the recommendations of my associates, in effect that water

works should be operated by public bodies. I dissent for the reason that my study of the report of the water works expert employed by your Committee, and my personal investigations, lead me to the conclusion that the water companies have made the more intelligent efforts toward adequacy and purity of supply, and that, all conditions considered, the result of their efforts has been and is a better and cheaper water supply and service than that maintained by the municipal water works departments.

I agree with the majority that such governmental conditions as exist in Glasgow, Manchester and Birmingham, are "distinctly favorable" to municipal ownership, as they must be to every urban activity, public or private. The fact that the results of the investigations we have made in these well-governed cities have not led my associates to commend municipal ownership as we have there observed it, or to recommend that our American cities adopt municipal ownership, is pregnant with meaning, and indicates another point upon which we are in accord.

My knowledge of the question, had from personal investigation, and from a study of the reports of the experts, employed by this Commission, and of the writings of its members, leads me to the conclusion that the city and citizens of Glasgow, Manchester and Birmingham, as well as of the other municipalities investigated, are not so well served by their public service trading departments as the cities and citizens of London, Newcastle, Sheffield, Dublin and Norwich are by companies operating similar trading industries, and that there is no element of blessing in the municipalization in the former cities to compensate for the indifferent character of the service rendered.

I dissent from the statement of my associates that "we take no position on the question of general expediency of either public or private ownership." I come from the study of this question, and from the investigations in which I have had a share, including that of the municipal plants selected as being the most successful in Great Britain and in this country, ready, and with confidence, to take a position on the question of general expediency.

Because the investigation, in which, through your favor, I have had the honor to have a part, has convinced me that municipal ownership has not proven equal to private ownership in benefits to the consumer, citizen or city, I am not able to agree with the majority of the Committee that the way should be left open for any municipality to undertake any trading operation, without special authorization by the Legislature of the State wherein it is located. I cannot believe that the prescribed remedy for any ill should be a worse ill, and I cannot recommend that a municipality suffering, or believing that it suffers, under company administration of a public utility, should be given the right to engage in the operation of such utility for itself, without such a course of procedure as will make sure that the sober second thought of the people shall have ample opportunity for development and expression, before the community is committed to municipal ownership, with the accompanying dangers and difficulties, of which you are warned in the majority report.

Because I believe that the general credit of municipalities should be conserved for the benefit of public and necessary improvements, from which, in the nature of things, private enterprise is excluded; and because I believe that a municipality should not be permitted in any event to engage in any trading enterprise that will not pay its own way, and have the confidence of the citizens as financially sound, I recommend that municipalities be prohibited, by statute, from making investments in trading operations, except with money borrowed on mortgage, or otherwise, the loan being secured by a lien on the plant in which it is invested, and on the right to operate the same, and on these only.

Because I believe that it is practically impossible to secure private funds for investment in an enterprise subject to purchase by a municipality, at a date to be selected by the municipality; and because I believe that the impossibility of so securing private investment may, and often will, work a social harm to a community, I dissent from the opinion of the majority that a city should have the right to purchase, at its option, the property of public service corporations for operation, lease or sale.

I believe in State regulation and protection of public service companies. I do not understand that your Committee was charged with the duty of recommending to you a form of regulation. I know that your Committee made no special study of this subject. Therefore I am not prepared to propose any detailed plan of regulation.

Finally, regretting to be in any degree in conflict of opinion with my associates, I may still satisfy my sense of duty to my fellow-citizens and my sense of obligation to you for the honor of a share in this important work, by recording the conviction I am under at the close of this investigation.

I am convinced that the condition of the British people, individually or collectively, has not been improved by the municipalization of the industries we have investigated.

I believe that political and social conditions in the United States are less favorable to the success of municipal ownership than are the same conditions in Great Britain.

I find this conclusion strengthened by our investigation into municipalized industries in the United States.

I am convinced that, under American conditions, the system of private ownership of public utilities is best for the citizens and the consumers.

I recommend State regulation and protection of public service companies, provided by statute, and as far as possible automatic in its application and operation.

I realize that in the main the majority and the minority of your Committee are in accord. Wherein we differ, the minority appeals with confidence to a careful reading of the records of your Committee for judgment as to the reasonableness of its conclusions and recommendations.

Respectfully submitted,

WALTON CLARK.

From a wide experience in the management of all departments of privately-owned public utilities, gas and electric, and the investigation of results obtained from public utilities of both classes, here and abroad, and particularly through having observed in the case of these and other municipal operations the difficulty, if not impossibility, of procuring under political

control adequate returns from the expenditure of time, effort, and money, I endorse fully the views expressed in this Minority Report.

> Even the Majority Report of this Committee stipulates that "no municipal operation is likely to be highly successful that does not provide for:
>
> "First—An executive manager with full responsibility holding his position during good behavior.
>
> Second—Exclusion of political influence and personal favoritism from the management of the undertaking."

I do not believe that these conditions in their entirety have ever been met in connection with the management of any municipal public utility in this country.

With Mr. Walton Clark "I am convinced that, under American conditions, the system of private ownership of public utilities is best for the citizens and the consumers."

I now turn to some of the questions which have to be met in the operation of public utilities privately owned.

It is argued that these public utilities should be regulated by the State because they are natural monopolies. True. But if we decide to regulate them, let us not forget the reasons advanced for so doing.

The history of the privately-owned public utilities of the United States is not a record of monopoly. On the contrary, it is a record of fierce and often destructive competition. And, even since regulation has been in force the companies, in many cases, have not been protected from attack by legislative action taken independently of the action of the regulating body. Furthermore, there is never complete monopoly in the case of these public utilities, as the needs of the people can generally be met through some other kind of service. This is particularly true in the case of gas and electric companies.

With Mr. Clark, again:

"I recommend State regulation and protection of public service companies, provided by statute, and as far as possible automatic in its application and operation."

But how far short of this is the regulation as generally practiced in the United States. The companies would will-

ingly, gladly, submit to regulation if they also were protected thereby, and if the regulation were as automatic in its application and operation as is practically possible. While there are exceptions to be recorded to the credit of a few strong, fair, courageous, and capable men who have been responsible for regulation as members of our Commissions, taken as a whole the record of regulation as applied by these commissioners to public service companies of the United States is far from creditable and frequently has been indecent.

Although this paper is intended to deal with public utilities of the municipality, I shall refer to the railroads also, and particularly because of the principles involved in commission regulation.

Beginning with the Interstate Commerce Commission, the result has not been for the benefit of the people as a whole. I do not say that some measure of regulation had not come to be necessary, but the Commission has gone far beyond the legitimate requirements and has exercised powers in conflict with the traditions of our form of government. In considering the questions under discussion we have to consider them with regard to the fundamental law of the land.

Thomas Jefferson spoke wisely when he said—

"Agriculture, Manufactures, Commerce, and Navigation, the four pillars of our prosperity, are most thriving when left free to individual enterprise."

It is true that conditions have changed since "the most conspicuous apostle of Democracy in America" gave this advice, but it is the same human nature we are dealing with; no better and no worse.

No doubt conditions had developed in connection with our industries and our commercial activities which required some measure of regulation under the law. These changes did not call for hasty and radical legislation in answer to public clamor, but for legislation based upon the widest experience, judicial consideration, and loyal co-operation of all interests concerned. As it is, regulation has developed, or rather degenerated, into such a measure of irresponsible control as threatens to destroy the activities upon which the prosperity and happiness of the whole people depend.

The necessary regulation suggested by the changes in methods of living since the time of Jefferson certainly does not call for the placing in the hands of a single department the power to exercise the three functions of government—the legislative, the executive, and the judicial,—the three functions which must be kept separated if our form of government is to be maintained.

Over-regulation and unnecessary interference with individual enterprise have been gaining headway year by year under Commission control. The tendency to allow one authority to exercise the three functions of government has been year by year more in evidence. The regulation of business in many cases has developed or degenerated into persecution. This burden necessarily falls most heavily upon the public utilities, including the steam railroads as the worst of sufferers.

It is sometimes offered by way of defence that the rulings of the Federal and State Commissions are subject to reversal by the Courts. So are the decisions of lower courts subject to review by higher courts, but nevertheless these lower courts exercise judicial functions.

It is significant in this connection to call to mind that the Interstate Commerce Commission has recently asked for an increase in its powers, and this example has been followed by some of the State Commissions.

Strangely enough it is the exception, or has been until lately, that a voice is raised against this revolutionary departure from this fundamental feature of our form of government.

The tendency of all of these Commissions, Federal and State, has been to get deeper and deeper into the details of management, to become more and more active in legislative work and the framing of rules, and to be more and more keen to sit as judges in the hearings or trials of public service corporations.

The last annual report of the Interstate Commerce Commission tells us that 7600 complaints were entered on the informal docket during the year, an increase of 455 compared with the preceding year. The investigation and suspension docket show 188 proceedings instituted, an increase of 45. On

the formal docket there were recorded 1081 complaints, an increase of 131; the number of cases settled being 822, the same as in the preceding year. There were 1461 hearings, an increase of 234, requiring 165,000 pages to record the testimony. There were filed 149,031 publications of rates, classifications, fares, and charges, an increase of 35,800.

The Commission of its own motion made 26 enquiries, including investigations of express companies, telephone and telegraph companies, and railroads. In addition Congress placed upon the Commission nine most important investigations, including that of the New Haven Railroad and the United States Steel Corporation. This should be enough to satisfy the ambition of men hungry for power, but in the report the Commission asks for more work and more power. And this request is made to the representatives of the party of which Thomas Jefferson is spoken of with pride as its "most distinguished apostle."

And Jefferson's advice, as before quoted, was that "Agriculture, Manufactures, Commerce, and Navigation, the four pillars of our prosperity, are most thriving when left free to individual enterprise."

If these faulty laws, laws giving too great powers to these commissions, were always or even generally administered with wise discretion and some restraint, if the commissions concerned themselves only or more particularly with the larger questions of principle and policy, the danger to our vested interests and the country's prosperity would be lessened. But the fact is that these commissions are coming more and more to concern themselves and exercise their authority with respect to the details of production, management, and administration. They exercise the authority while avoiding responsibility for the final results—a most dangerous system.

Also, the hearings or trials are too often conducted in a way to indicate decided bias, and the public service companies' witnesses are not given the same consideration as the witnesses for the complainant or the commission. The commissioner who conducts the hearing takes part in the examination of witnesses. To this there is no objection, but to the contrary, provided the effort is made to develop from each and every

witness the truth, the whole truth, and nothing but the truth. This is the duty of the commissioner sitting. But, unfortunately, the commissioner too often uses his power to confuse the timid and stupid witnesses, and to distort the statements of the competent witnesses. In other words, the commissioners too often, while sitting as judges, are acting as prosecutors. I have myself observed cases of this kind that were shameful.

That there may be no misunderstanding, I repeat that there are exceptions, men who are doing their utmost to make the best of a bad proposition.

It has been well said that the regulation of our public service corporations has practically resulted in their strangulation. It should be evident, even to the commissions and others responsible for these conditions, that there is one element in this problem which cannot be regulated or controlled by foolish law-making and over-zealous enforcement, namely, the investor.

Perhaps we are able to see a change for the better in the present attitude of the Federal authorities towards business in general; and if there is a change it is due to the fact that the people are coming to see that what affects business affects them. It is their ox which is being gored.

The lack of success which the Federal Government has experienced in its radical efforts to enforce the Sherman Law is instructive as showing a change in public opinion; an influence which is potent with the politicians in this country. It is being discovered—and it is truly a discovery to some high in authority in Washington—that there are many corporations doing business on a large scale and yet doing it honestly, and that it is not good sense or good morals to carry on the government on the general premise that men are necessarily or preferably dishonest because they are engaged in commerce or banking. Let us hope for the common good that in this respect we are entering upon a new era, and that the governments, Federal and State, through their commissions and other agencies, from now on and for some years to come will be found assisting business to recover from the wounds inflicted of late years by these same agencies, wounds which have proved fatal or permanently disabling in too many cases.

There are many directions in which fairer and more sensible lines can be followed in the regulation of the public service corporations. I shall not attempt to cover the field but I shall refer in some detail to a few of the more flagrant cases of injustice to these interests.

In the accounting methods prescribed there is found far too much of the influence of the doctrinaire and inexperienced accountant. It is almost a misuse of terms to speak of an inexperienced accountant, for an accountant, as differentiated from a book-keeper, should be one skilled in the business as well as in the accounts.

While it is true that some of the commissions have consulted with the companies in developing their uniform systems of accounts, still it remains that in some important details, and particularly on questions of principle, the orders placed upon the companies are unfair in the extreme and finally spell confiscation. If the public service corporations were as open to criticism for not fully disclosing and for misrepresenting the facts as are some of the departments of the Federal, State, and Municipal Governments of our country, then indeed would there be need for even stricter regulation than at present, and this same comparison could have been justly made before the days of regulation.

In the one question of depreciation, so-called, we find flagrant injustice being done. While the practice with respect to writing off for "depreciation" and deducting therefor in valuations is not uniform as to details with the commissions, and is still less so with the Courts, the practice in general is in one way or another to deduct from the appraised value of a public service property in proportion to the age of each of its parts as compared with the expected life; and this even if the property has been kept up to the highest degree of operating efficiency by the liberal and well directed expenditures for current repairs and minor renewals.

First, let us suppose that the total annual expenditures for maintenance of the plant, including repairs and all renewals and replacements, is found to be fairly constant in amount, and that the property is thus maintained in a condition of maximum or practical efficiency; then there no longer

exists the need to provide for any accruing liability for deferred, periodic, or final renewals. Then it follows that the investment is kept intact, and all possible is being done to protect the property and to protect the consumer against overvaluation.

This proposition still holds good although there may be and probably will be a liability for the period prior to the time when this condition of complete maintenance of the property by the practically constant rate of annual expenditure developed. This last condition simply means that the liability as to the past has reference to certain items of renewal which are being liquidated by a certain portion of the annual current expenditures, the accrued liability being shifted to certain other portions of the plant yet to remain in service. Nothing more can be done by the owners of the property than is thus being done to keep the investment intact, and as the service is thus kept up to a maximum of efficiency, to deduct for this accrued liability for so-called depreciation does spell confiscation.

Suppose that this reserve or liability for renewals had been correctly estimated on the sinking fund basis—which is the scheme most generally approved by the Commissions and Courts—then the interest on this reserve balance will be continually required to maintain that portion of the renewal fund up to 100 percent as the parts originally covered in the original computation continue to be renewed from time to time as provided in the original estimate. Here it is not to be forgotten that in practice there cannot be in the case of a growing property a complete cycle. A complete cycle would require that it be measured by the part of plant of longest life, which must then be a multiple of the lives of all the other parts. In practice, even if the plant were not growing, there could hardly be any such condition; and as a result, at the end of the longest life, there would be an overlap of liability for the parts whose lives were not factors of the longest life. Then in this case, when the condition of practical uniformity in annual maintenance expenditure developed, there will be at the end of the so-called cycle a liability for the renewals shown by this overlap, and there should be in the reserve plus the interest to accrue an amount equal to this overlap of liability. The

interest on this balance to credit of reserve would be part of the annual requirement and annual expenditure for renewals and replacements. In other words, this balance in the reserve account is required to cover the accumulated liability for deferred renewals at the time the annual expenditures therefor became practically uniform. Again I say, then, that everything possible has been done to maintain the investment at 100 percent; and if a deduction is made under such circumstances to cover so-called "depreciation", the investor at the beginning of the undertaking is entitled to regard such deduction as one of the necessary costs of the plant, and so he should be entitled to include this as an item in the estimate of cost and so be entitled to earn a return thereon on the same basis as any or all other items of first cost. This being the case, it is simpler not to include this cost of renewal item as an item of first cost and not to deduct for "depreciation". This is emphasized by the fact that no accurate estimate could be made in advance of this item, for it would vary with the portion of the cycle selected.

There would be less confusion in connection with this much discussed question if it were generally understood that the term "depreciation" is a misuse of the term when applied to the cost of renewing plant required for continued operation, which has to be retired by reason either of decay (or wearing out), inadequacy, or obsolescence.

The cost of renewals and replacements due to any and all of these influences is a necessary cost of the maintenance and operation of the plant, and is now generally acknowledged as a legitimate item of operating expense. If it were not so, confiscation of the investment would begin with the first year of operation and would continue until the original investment were completely confiscated. The term "depreciation" should only be used to cover the disintegration or deterioration of plant which is not covered by repairs and renewals as required for efficient and economic service. To deduct from the appraised value of a plant in a rate-making case when the plant is completely maintained for efficient service, because of the estimated expired life of the several necessary parts of the plant, cannot be anything short of confiscation.

This can be made plainer by answering the following question which is frequently asked by those who advocate such deduction for "depreciation" in the belief that the answer must be in favor of their proposition:

If you were buying a plant would you not demand a deduction from the cost new to cover this item of depreciation?

The answer is, Yes. But this is in complete accord with the proposition that "depreciation", or the accrued liability for deferred renewals, should not be deducted in a rate-making case against a public service corporation continuing to hold and operate the property.

If I buy the plant, I have to assume this accrued liability for deferred renewals and hence a deduction should be made in my favor to cover this liability. Or, if the accrued liability or reserve were offset by an invested fund accumulating at compound interest, and I were assured by expert examination that this sinking fund fully covered the accrued liability, I would demand no deduction provided the fund came to me with the plant.

This renewal reserve does not, or should not, represent plant which has disappeared, not to be renewed or replaced, but plant which is to be kept in being for service by such renewals or replacements when the proper time comes therefor. Again, this should not be confused with cases where, in the exercise of good engineering and business judgment to secure greater efficiency, a certain part of the plant has been retired before the expected life termination. This is a case where it may be considered more prudent not to keep this portion of the plant cost on the books finally and, instead of charging this lost item against a single year, the loss might be spread or amortized over such a number of years as the judgment of those in charge might decide. This is a special case requiring special treatment and so means final retirement of that part of the investment instead of renewal or replacement.

I have thus first considered the case of a public service corporation whose property or properties taken as a whole have come to a condition of practically uniform annual expenditures for maintenance, including deferred renewals.

This condition may be found in large railroad systems and other public service corporations controlling and operating a number of plants or properties.

But the case which now requires careful consideration is that of properties which have not reached and perhaps never will reach this condition.

In a single plant there will from the start begin to accrue a liability for the deferred, periodic, or final renewals or replacements. If this accruing liability is not taken account of in the financial statements, the profits will be over-stated. As in the case of all accruing liabilities, this one must be carried into the books of account if the owners are not to deceive themselves.

This liability cannot be determined accurately. It is a matter of estimate, necessarily. The estimate must have for its basis the probable life of the plant, taking into account wear and tear or decay, obsolescence, and inadequacy. The several parts of the plant have to be considered separately in developing the life table.

If, by giving each part its cost weight, the average life of the plant so estimated is found to be fifty years, then the annual loss to cover deferred renewals, in addition to current expenditures for repairs, will be one-fiftieth or 2 percent of the cost.

If this total is charged to Loss and Gain Account for the year and credited to Renewal Reserve we have the so-called "straight-line" method.

The deferred renewals—if our life table is correct—will not actually cost this 2 percent, because the fund can be invested and allowed to compound during the fifty years.

If, for the sinking fund method, we assume a rate of interest of say 4 percent, the 2 percent of cost for the fifty years life through the interest accumulations is reduced to 0.66 percent.

This reserve may be placed in a sinking fund to accumulate or it may be loaned at 4 percent to the general fund for the extensions and betterments which would otherwise call for that much new money.

In this last case the reserve is being added to annually

by the 0.66 percent charge to operating cost to cover the estimated liability for deferred renewals plus the interest on the balance in the account, and is being reduced from time to time as the parts of plant included in the expectation-of-life table come to be renewed or replaced. Then all parts of plant which at any time appear in an inventory or appraisal as having been paid for from the renewal reserve fall in one or two classes:

(1) Parts which have been installed as renewals or replacements and are, therefore, in place of parts represented in the original investment and hence to be included in the inventory as such.

(2) Parts of plant which have been installed as extensions or betterments and which have been paid for by money borrowed from the renewal reserve. These parts should, therefore, be included in any inventory or appraisal because they are not a duplication of investment, but represent additional and segregated investment which has to earn interest for the sinking fund, this interest being apart from and in addition to the earnings on the original investment. If deduction for "depreciation" as represented in the renewal reserve is made from the appraised value new, then the company is unable to earn the interest which it owes to the sinking fund; and unless this interest is so earned and added to the sinking fund, the cost of renewals will not be provided for as contemplated in the expectation-of-life estimate.

Then it should take but little thought to see that this renewal reserve covers a condition of constant change; and as in the first case covered—the condition of practical uniform annual renewal expenditures—there is no sound basis for deduction from the appraisal because of this provision in the accounts for spreading over the years of service through a uniform annual charge the total cost of the renewal of the several required parts of the plant.

This liability for subsequent renewals, which is erroneously called "depreciation", is not the reduction in worth or value as viewed by a possible purchaser, but is the accrued liability of the owner to renew all parts as these parts become uneconomical, inefficient, or inadequate.

As long as the property does not change hands, the own-

ers are obligated to make all necessary renewals; and if the property does change hands, the new owner has to assume this obligation. This statement alone should be a sufficient negative to the claim for deduction on account of the aging of a plant constantly maintained for adequate, economical, and efficient service.

Before leaving this part of my subject let me repeat—for it is a matter of vital importance to the investors of the United States, small as well as large—that the conspicuous confusion of thought and argument on this subject is largely due, in my opinion, to the misuse of the term ''depreciation'' to cover the cost of deferred or periodic renewals.

The question of ''depreciation'', or renewal cost, naturally leads to a consideration of the physical valuation of public service properties in connection with the fixing of rates for service. This is too large a subject to cover, even if the whole of this paper were to be devoted to it, but it should now be evident from experience that this much-advertised basis for determining a fair rate of charge has not proved to be a success.

The experience so far in the case of public service properties, including railroads, has been unfavorable to the investors and has resulted in confiscation in varying degrees.

In some cases it has been the decision of the commissions that the ''bare bones'' of the plant, to quote Judge Lurton, only have been included in the appraisals. Gradually, the commissioners, or some of them, have been forced to see that allowances must be made for items not covered by the valuing of the items on the schedule of the plant as disclosed to the eye. They have also learned by experience that these schedules of the visible plant as prepared by their employes are often incomplete.

It has been driven home that there are such legitimate items of cost as preliminary expense; legal and other organization expense; engineering, including design; superintendence, including supervision; contractor's expense; interest on all expenditures, say for one-half of time occupied in construction; taxes during construction; cost of financing; and contingencies. This last may be a large item, as might be illustrated in such undertakings as the construction of the New York Central Ter-

minal in New York City, the elimination of grade crossings, the building of city subways, etc.

One of the reasons why it has been so difficult for the commissions to be persuaded of the magnitude of these items of cost outside of the inventory is that so many otherwise competent engineers have in the past failed to appreciate what a large percent of the total cost is thereby absorbed. When we come to the valuation of the steam railroads of the country we see at its worst the evils of this basis for rate-making.

The cost of this work will run far up in the millions both for the companies and the government, and when the valuations are completed these valuations already will be obsolete.

It was originally estimated that the cost of valuation would be about \$10 a mile. On the New Haven Railroad they find about 800 miles a year only can be valued, and it is stated that the company's pay-roll on this account alone is \$145,000 a year. On the basis of \$10 a mile it was estimated that for the entire country the cost would be \$6,000,000. The latest estimate is said to be \$50,000,000. The man who made the estimate of \$10 a mile should be put under cross-examination and given an opportunity to explain by what marvelous process of analysis or reasoning he arrived at this figure. I have no doubt that the direct and indirect cost will far exceed the last estimate of \$50,000,000.

It is only necessary to see how this work is being done to realize its deficiencies; large questions neglected for want of adequate experience, and trifling details magnified beyond recognition.

One thing will result which will be of value to the railroad companies, provided they can secure anything approaching fair play,—it will be demonstrated that many, if not most, of the large railroad systems of the United States can show a physical valuation in excess of their total bonds and stocks. In other words, it will be found that the "water" is a minus quantity. But the losses already incurred by the railroads and, therefore, by the people as a whole are now only beginning to be generally understood.

In 1906 the quotations for railroad stocks averaged about 138. Today this average has fallen 48 points. The latest re-

turns show that the railroads are taking in a trifle more money than in 1914. The net revenue is about $10,000,000 above last year, but the increased profits are made up by reduction of expenses from $140,000,000 to $130,000,000. This reduction in operating expense may be represented by failure to fully maintain the properties. One eighth of the railway mileage is in the hands of receivers. In more than one case the stockholders have to face an assessment of $50 a share or a total loss. But the loss does not fall on the stockholders alone when we find that the average number of railway employes has fallen in one year from 1,815,239 to 1,695,483. The country's advance in prosperity depends upon the railways being able to make extensions and betterments. Only the strongest railways have of late been able to make any extensions. The total new mileage is negligible, whereas, a few years ago the railways were extending thousands of miles each year.

In 1902 the railways paid in taxes an aggregate of over $54,000,000, amounting to 8 1-3 percent of their income. Now they are paying over $140,000,000 in taxes, amounting to nearly 16¾ percent of their income; an increase in the period of almost 160 percent. This increase of $86,000,000 a year would pay 5% on $1,720,000,000.

In the rate case recently argued in Washington it was shown that the present average return on railroad capital is less than 4 percent, while railways of established credit at the time of the hearing were having to pay as high as 7 percent on the renewals of short time notes.

This comparison explains why the railroads not only have to curtail or discontinue their extensions but have to skimp their maintenance charges.

This persecution of the railroads—for it is nothing short of this—is the harder to understand when we bear in mind that the railroads of the United States compare most favorably with the railroads of Europe in capitalization per mile, rates of charge for passengers and freight, character of service, and wages paid to employes.

The railroads have suffered a grave injustice at the hands of the National Government through the Post Office Department and particularly in connection with the Parcels Post.

Ex-President Taft in a letter made public some little time since speaks of the Parcels Post as "a great step forward in methods of cheap transportation for the people". But then he goes on to say—"there is one thing connected with the Parcels Post that ought not to meet the approval of anybody and that is that we have not given to the railroads appropriate compensation for the additional burden that they have to carry by reason of the Parcels Post, but after a time Congress will see its duty and make reparation in this regard, I hope".

It is to be noted that the Ex-President only expresses a hope that Congress will act honestly in this matter.

Even President Wilson, who at first certainly did not show any disposition to favor the railroads or big business in general, wrote thus in September 1914, in answer to an appeal of the railroad managers:

> "You ask me to call attention of the country to the imperative need that railway credits be sustained and the railroads helped in every possible way, whether by private co-operative effort or by the action, whenever feasible, of governmental agencies, and I am glad to do so, because I think the need very real.
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> The interest of the producer, the shipper, the merchant, the investor, the financier, and the whole public in the proper maintenance and complete efficiency of the railways is manifest. They are indispensable to our whole economic life, and railway securities are at the very heart of most investments, large and small, public and private, by individuals and institutions.
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> I am confident that there will be active and earnest co-operation in this matter, perhaps the one common interest of our industrial life.
>
> But the emergency is, in fact, extraordinary, and where there is a manifest common interest we ought all of us to speak out in its behalf, and I am glad to join with you in calling attention to it. This is a

> time for all to stand together in united effort to comprehend every interest and to serve and sustain it in every legitimate way."

Let us hope that the men in authority who, for the last few years particularly, have been so aggressive and persistent in their attacks on the railroads, the other public utilities, and business in general will take their cue from this utterance and understand that they have either over-stepped their instructions or else that their instructions have been moderated if not radically amended.

The recent victory of the United States Steel Corporation is, perhaps, an indication of a changed attitude towards business. Those in charge of this case for the corporation deserve the thanks of the people as a whole for the important victory they have won, though they may have to wait for the verdict of a future generation for the acknowledgment of this obligation.

If those in authority choose to explain this decision by saying the trusts are now conducting themselves properly, let us not object if this helps them to be more just and discriminating. Let us hope that we have now started on a saner and healthier course of regulation, where unfair business practices will be condemned and eliminated, but where honest practices will be not only approved but encouraged. Let us hope particularly that we are now to emerge from the morass where honest men neither knew themselves how to so conduct their business as to keep within the requirements of the law nor were able to obtain the necessary guidance from able legal advisers. Let us hope that regulation of business shall cease to take the form of strangulation, and that prosecution of the guilty shall not be made an excuse for persecution of the innocent. Here I am not losing sight of the unfair and dishonest practices of some corporations. Such practices will never be completely eliminated, nor will the efforts to eliminate such practices be more successful by failure on the part of government officials to discriminate between honesty and dishonesty.

I have purposely devoted much space to the discussion of the railroad problem as involved in regulation.

The problem is the same as in the case of the municipal

public utilities except as to details. The records of municipal public service regulation, if complete and truthful, would show injustices far more often against the corporations on the part of the regulators than injustices against the public on the part of the corporations.

From my personal experience I believe that the public service companies generally are more willing to be frank and fair in the investigations had before the commissions than are the representatives of the municipalities or the commissioners themselves.

I am reminded of the opinion expressed by one able member of one of our most important state commissions, who, after serving his five years, stated in a public address that when he took office he was prejudiced against the public service corporations, believing that they would not be open and frank in their testimony, but during the five years of his service as a commissioner he had gradually but surely been driven to the realization that the representatives of these corporations could be relied upon to exhibit greater candor and desire to coöperate for the common good than could the representatives of the cities, the State, or the people.

There is one direction in which the efficiency of these commissions, Federal and State, can be greatly increased; namely, by having on each board at least one well-trained, experienced, open-minded, fair and courageous engineer. Not that a man should be appointed to one of these positions of tremendous responsibility and power simply because he is an engineer, but that with all other necessary qualities, so hard to find, he should also be an engineer. A man is no more qualified to act as a public service commissioner simply because he is an engineer than is a man qualified to act as a judge simply because he is a lawyer. But the judge needs to be a lawyer; and, as most of the questions coming before these commissions involve engineering, at least one engineer should be on the board.

Not long since this proposition would have been scouted, and it would have been and was generally said that the engineer should not be a member of the board but only a paid member of the staff.

It is, then, encouraging to find that Judge Prouty, for-

merly Chairman of the Interstate Commerce Commission and now Chairman of the Federal Board for Valuing the Railroads, and Professor Daniels, now a member of the Interstate Commerce Commission and formerly a member of the New Jersey State Commission, have recently advocated the appointment of competent engineers as members of the commissions.

Judge Prouty made public acknowledgment of his change of view on this question in an address before the American Railway Engineering Association. He stated that he was originally of the opposite opinion but his experience as a commissioner had completely changed his views. He stated that he had been "told that an engineer could measure and figure with accuracy, but that he was not competent to discuss the intricate problems presented by the valuation of our railroads, and that we must be very careful not to let him undertake to discuss them. I am fast coming to the conclusion that he may be better qualified to discuss them than anybody else." He goes on at a considerable length to argue this proposition while still maintaining his loyalty to his own profession by claiming it is the greatest of all professions.

Professor Daniels, in an address delivered before the Washington (D. C.) Society of Engineers, also advocated the placing of the engineer on these boards. He said in part:

> "Going one step farther, in the domain of government regulation of public utilities the engineer has been called upon to furnish a just basis on which to predicate the approval of security issues. Here the respective interests of the corporation, the consumer, and the investor have been weighed in the engineering scales, and last of all and most important of all, we have had to resort to the engineer for the data indispensable in the fixing of just and reasonable rates for the service rendered to the public by various public utilities. In all this varied and complex matter of public administration the engineering profession has evidenced its ability to grasp these problems of public equity and justice."

I by no means hold that the placing of engineers, even of the highest character and attainments as to theory and prac-

tice, would be a cure-all for the evils from which we are now suffering. It would lead to improvement in the line of efficiency and equity. But the system is wrong in itself in that these bodies exercise too much power, and particularly, as already referred to, in connection with the three functions of government, which should not be placed in the hands of one man or body of men.

Under the system as now practiced there is no reward to the owners or managers of public utilities for good management—for that greater economy and efficiency which operate for the benefit alike of the seller and buyer of service.

Let me point out one item simply by way of example. Suppose it is in the line of increased economy and efficiency to abandon a certain part of the plant. Suppose it is so abandoned and thereafter there is an appraisal made by a commission as the basis of a readjustment of the service rates to be charged. This abandoned plant would be omitted from the appraisal and as a result the step which had been taken in the interest of economy is made the basis for a reduction in the rates. Here is an instance where there should be an honest co-operation between the public service corporation and the commission, a co-operation which at present is too generally not in evidence.

This and many other examples could be given to show that there is under present conditions no incentive to the promoter (and there are honest promoters, and this country is much indebted to them) to take up new undertakings or even to expand and extend the established properties. This means finally lack of progress, for new money must be brought into these undertakings through prospect of more than a minimum rate of return.

In the conduct of our public utilities—railroads and municipal utilities—we should not permit the present strangulation of business to continue but we should return to reasonable regulation.

In reviewing this whole situation with respect to the attitude of the public and their representatives in legislative bodies and public office toward the public utilities, it must be acknowledged that the blame for the many and great injustices

done to these companies does not rest entirely on those who have inflicted the injuries.

The managers of many of these properties have failed to demand courageously and insistently the fair treatment which is their right.

Not only should the managers of these properties do their utmost to educate the public and their official representatives, but they should be more frank and more diligent in educating their own stockholders in the questions involved—many of them complex—and so enlist their co-operation for their own protection.

Finally, concerted action in the open should have been taken by representatives of the public utilities, and with the co-ordinated co-operation of their stockholders, to enforce the demand that their investments should under the law be protected from confiscation.

This feature of the situation is well illustrated by a remark made to me by a member of one of the most influential of the State Public Service Commissions. I was warning this Commissioner that in my testimony about to be presented in a case before his Board that I should be frank in my statements, let them hit where they might—the corporation under fire, the complainant, or the commission and its employes. The Commissioner's reply was to the effect that their great difficulty was to learn all the facts, and if through timidity or a fear of exposing certain weaknesses, the public service corporations failed to be completely frank with the commission, the commissioners must necessarily fall into errors and the blame therefor must then rest on the corporations under examination.

Many of my own experiences with managers of these properties, and still more with the bankers interested, show that those of us who believe it is not only right but also the best policy to be frank are apt to be regarded as unsafe advisers.

These men in control are fearful that a full presentation of the histories of their companies would reveal practices and policies of the past that would count against them. I am convinced that if such a record of all the public utilities of the United States were disclosed to the public, although there would certainly be found in the case of some corporations the

record of unfair or corrupt practices, the record as a whole would present a far better condition than is the picture now in the minds of the public. In other words, there have been things done which were wrong at the time of doing and which would be still more reprehensible under present conditions of law and sentiment, but these unsavory things have been magnified in the eyes of the public and their representatives, as is always the case when the facts are hidden or not fully disclosed. It is a human weakness to magnify charges against our neighbors rather than to minimize them.

In connection with the past records of these corporations I refer to the admirable report of the Federal Railroad Securities Commission, of which President Hadley of Yale was Chairman.

The remedy, then, for the present deplorable conditions surrounding the railroads and other public utilities and business in general is to be found in an honest, determined, persistent, courageous effort on the part of these interests, acting together as far as is humanly possible, to protect their property rights. Here the strong men must be prepared to see to it that the claims made are fair to all concerned.

To carry out such a campaign the stockholders of the corporations must first be educated and interested, and then, with the help so secured, the public must be educated.

And this course of education must be carried on in the open without apologies and as a matter of common right and justice.

Since writing this paper the Committee on Industrial Relations of the Constitutional Convention of New York has reported this extraordinary amendment:

> "The Legislature may delegate in its discretion to any duly constituted commission, board, or administrative agency power to make rules and regulations supplementing, varying, modifying, adapting, or otherwise applying to existing conditions laws passed for the protection of the lives, health, comfort, or general welfare of employes."

If such a provision were made part of the fundamental law of the State of New York, it would work a more radical

departure from the traditions of our Government than has ever yet been attempted. It would place in the hands of a single board or administrative agency almost unlimited power in connection with the labor question.

Apparently, in my paper, I have not over-estimated the dangers which threaten our liberties.

DISCUSSION

Mr. O'Shaughnessy. **Mr. M. M. O'Shaughnessy,**† M. Am. Soc. C. E., in opening the discussion referred to many predictions that San Francisco would be incapable of operating a public utility at a profit. However, the Municipal Railroad, with an investment of $5,000,000, has had for the past year receipts amounting to $2,000,000. This compares very favorably with the figures on the Panama Canal, which, with an investment of $360,000,000, had receipts amounting to $4,000,000 during the first year's operation. The success of the Municipal Railroad in this city depends upon good men being retained in office. Undoubtedly every city should own its own water supply, and of the large cities, only San Francisco, Oakland and Denver do not own their water-works systems.

Mr. Brinkley. **Mr. M. H. Brinkley,**†† Assoc. M. Am. Soc. C. E., desired to dissent from the statement made by the author of the paper, that cities should not be allowed to take over public utilities. Being a believer in the Home Rule theory for cities, he thought that each city should be allowed to work out its own problems. While the writer of this paper seemed opposed to regulation, he believed that regulation is merely a step to public ownership, and that public ownership is the ultimate solution of the question. To his knowledge there have been no cases of any consequence of cities returning to private ownership after they have once controlled their utilities.

Mr. Ransom. **Mr. T. W. Ransom,**** M. Am. Soc. C. E., expressed the opinion that Mr. Humphreys' paper was extreme in its views. From the experience of San Francisco in municipal ownership, he believed that the citizens are brought thereby to a closer knowledge of and interest in the Government. Business men, for example, take sufficient interest in the fire system to see that its efficiency is not affected by politics. While Mr. Humphreys assumed that the operation of a public utility is for the sole purpose of making money, there are nevertheless larger questions of public welfare at stake. He expressed the opinion that the cities of the United States are not better prepared to undertake municipal ownership because so few of them have attempted it, and there is so little in the way of useful precedent. As an example of the advantage of municipal ownership, he referred to the Richmond and Sunset Districts in the City of San Fran-

† City Engr., San Francisco, Calif.

†† Asst. Engr., State R. R. Comm., San Francisco, Calif.

** Consult. Engr., Board of Works, San Francisco, Calif.

cisco. The Sunset District, although perhaps as desirable as the Richmond District, is not so valuable, due to lack of transportation facilities. If a railroad were built through this Sunset District by a private corporation, then the corporation must stand a loss for the first few years until the section becomes built up, and afterwards make up for this loss. Municipal ownership could handle this by taxing property owners directly, when receiving the benefit of transportation facilities. Mr. Ransom.

Mr. A. H. Dimock,†† M. Am. Soc. C. E., referred to the pronounced modern tendency towards municipal ownership. In New York the new constitution providing for a short ballot will tend to concentrate responsibility and increase the efficiency of the municipal government. In Seattle, when the question of building a municipal power plant first came up, the rate for electric power was 20 cents per kilowatt hour; whereas, on the completion of the municipal plant, the cost was reduced to 6 cents per kilowatt hour. This plant was as efficiently managed as any plant privately owned. When the point is reached where the money of the people can be saved by municipal ownership, it is high time that such system be adopted. Mr. Dimock.

Mr. H. C. Vensano,‡ M. Am. Soc. C. E., expressed the opinion that the greatest danger in connection with municipal ownership lies in the possibility of poor officials and instability of the government. On the other hand, one of the great advantages is the ability of cities to borrow money more cheaply than private corporations. He also referred to the difficulty of extending the system of municipal ownership to small cities, and to the disinclination of private corporations to give small cities adequate service, with the likelihood of the system being later taken over by the city. These conditions tend to prevent adequate service in small towns. Mr. Vensano.

Mr. W. C. Rommel,‡‡ Mem. A. I. E. E., expressed the view that the solution of the question of public ownership will lie in the adoption of the non-partisan commission form of government, when technically-trained engineers will have far greater opportunity to fill positions of responsibility in the administration of public utilities under public ownership. Mr. Rommel.

Mr. R. F. Schuchardt,*** Fel. A. I. E. E., said that no common ground can be reached on the discussion of the subject of municipal or private ownership. It must always be remembered that private corporations, for their best interests, will always operate for the consumer's benefit, and due to greater efficiency methods, can make more of these benefits available to the consumer. Mr. Schuchardt.

Mr. S. S. Wyer,* Mem. Am. Soc. M. E. (by letter), gave the following instances of municipal undertakings in the way of natural gas plants: Mr. Wyer.

Urbana, Ohio (Pop. 6,800) in 1889 issued $250,000 of 6 percent general municipal bonds, leased ground and drilled natural-gas wells in the

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‡ Civil and Hydr. Engr., Pacific Gas & Elec. Co., San Francisco, Calif.

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*** Elec. Engr., Commonwealth Edison Co., Chicago, Ill.

* Consult. Engr., Columbus, Ohio.

Mr. Wyer. old Findlay, Ohio, field, and built about 40 miles of pipe into the field, and a distributing plant in Urbana. In 1898 the city sold its property outside the city for $15,000 and leased the operating plant to a private company for twenty years at a rental of $3000 per annum, which, however, made it necessary for the city to make all extensions. This plant was a complete financial failure. All interest and principal for the bonds was paid out of general taxation. In 1897 the city defaulted its bond interest, and then compromised by having the bondholders change the interest from 6 percent to 4½ percent; $55,000 of bonds which matured between 1903 and 1909 had to be refunded. The last $5000 of these will be paid in 1916.

Between 1889 and 1892 the City of Toledo, Ohio (Pop. 81,343), issued $850,000—4½ percent bonds to build a municipal gas plant. In 1901 the property was leased to a private company for an annual rental of $6500. There are still outstanding $350,000 of bonds, on which there is an annual interest charge of $15,750. All interest and sinking fund for retiring bonds have been paid out of general taxation.

Tiffin, Ohio (Pop. 10,801), issued $500,000 of municipal bonds to build a municipal natural-gas plant, and in 1897 sold the entire plant for $27,000. The bonds had to be refunded, and $112,000 are still outstanding.

Upper Sandusky, Ohio (Pop. 3572), issued $80,000 worth of bonds in 1889 to build a municipal natural-gas plant. The property was sold in 1902 for $10,000. The interest and sinking fund for the bonds were obtained from general taxation and not from gas earnings.

Findlay, Ohio (Pop. 18,553), built a municipal natural-gas plant in 1886 and sold it to a private company in 1889. The last bond was paid in 1907. The interest and sinking fund were paid out of general taxation, and not out of municipal gas-plant earnings.

Fostoria, Ohio (Pop. 7070), built a municipal natural-gas plant in 1885, but soon sold out to a private company. No original records at all are now available, but the general impression left is that it was one of the worst ventures the city ever went into.

Mr. Holcomb. **Mr. H. C. Holcomb*** pointed out that the main feature in the consideration of municipal ownership may not be revenues but may more properly be public welfare. The operation of certain horse cars in San Francisco merely for the purpose of holding down franchise rights, is an example of the tendency of privately owned corporations to put personal gain above public welfare.

Dr. Humphreys. **Dr. A. C. Humphreys** (author's closure by letter) called attention to the fact that the paper was presented in his absence and necessarily in abstract and that he had not been informed as to the special points covered in the abstract. From a reading of the discussion he was led to believe that some of those participating had not read carefully or did not have in mind the paper itself. He was of the opinion that practically

* Ass't City Engr., San Francisco, Calif.

all of the points raised in the discussion had been met in advance, but would submit further comment on the points as raised. Dr. Humphreys.

Replying to Mr. O'Shaughnessy, he pointed out that even though the receipts from the Municipal Railroad of San Francisco for the year may be $2,000,000 on an investment of $5,000,000, this does not prove that the property is managed efficiently or economically. He expressed no opinion as to the results, as he was not informed as to the facts. He simply held that the argument was inconclusive nor did he see that the reference to the Panama Canal had any bearing. He agreed that the "success of the Municipal Railroad in this city (San Francisco) depends upon good men being retained in office". In this connection, he desired to refer to a point in his paper where he endorsed the views expressed in the Majority Report of the Civic Federation:

"No municipal operation is likely to be highly successful that does not provide for:

"First—An executive manager with full responsibility, holding his position during good behavior.

"Second—Exclusion of political influence and personal favoritism from the management of the undertaking".

Even this majority report, signed by warm advocates of municipal ownership, warns against "the danger here in the United States of turning over these public utilities to the present government of some of our cities". It may be, and he hoped that it is, that San Francisco is not to be included in this warning.

He did not agree that "there is at present no way of preventing small companies from starting competition with the idea of forcing larger companies to buy them out". Distinctly that is one of the responsibilities of our Public Service Commissions, a responsibility to which they should be held to strict account.

Replying to Mr. Brinkley, he wished it to be understood that he also believed in Home Rule for cities. But that does not prevent the citizens, so responsible, studying all questions involved in the light of experience, instead of exclusively through the teaching by doctrinaires.

He did not consider Mr. Brinkley warranted in stating that he (the author) was opposed to regulation. The paper speaks for itself, and he desired to refer to his statement: "With Mr. Clark, again, 'I recommend State regulation and protection of public service companies, provided by statute, and as far as possible automatic in its application and operation' ".

Again, mention is made with approval of "regulated monopolies"; and at another point occurs the statement: "I do not say that some measure of regulation had not come to be necessary, but the Commission (Interstate Commerce Commission) has gone far beyond the legitimate requirements and has exercised powers in conflict with the traditions of our Government", and on the same page: "No doubt conditions had developed in connection with our industries and our commercial activities which required some measure of regulation under the law".

Dr. Humphreys. Again, at another point, is found the statement: "In the conduct of our public utilities—railroads and municipal utilities—we should not permit the present strangulation of business to continue, but we should return to reasonable regulations".

Mr. Brinkley acknowledges that regulation is merely a step to municipal ownership. He agrees with Mr. Brinkley that this is true with regard to over-developed regulation, and therefore for safety we must retrace our steps.

It may not be within Mr. Brinkley's knowledge that there have been "cases of any consequence of cities returning to private ownership after they have once controlled their utilities", but it can come within his knowledge if he examines the records with some degree of diligence. A notable case of surrender of municipal control is that of the Philadelphia Gas Plants. There have been other surrenders of gas properties and of many electric properties.

Mr. Wyer, in his written discussion, gives in some detail the results of a number of municipal natural-gas undertakings which have proved to be burdensome upon the taxpayers instead of themselves being taxpayers. He wished to refer Mr. Brinkley and all others interested (and all citizens should be interested) to "A List of Defunct Municipal Lighting Plants", Ninth Edition, compiled by Arthur Hastings Grant, and published by the Municipal Ownership Publishing Co. This list includes 211 of these municipalities.

By way of explanation he quoted from the beginning and ending of the preface: "In view of the persistent suppression by advocates of municipal ownership of the real facts in regard to municipal lighting plants, it has seemed worth while to prepare a list of municipalities which have wholly or in part gone out of the lighting business by the sale, lease, or abandonment of their plants. In almost every case information has been sought first from the mayor or city clerk, and in cases where no response has been received from them, application has been made, as far as possible, to disinterested persons, such as the editors of local papers.

"In a number of cases (indicated by an asterisk) these cities still maintain their distributing plants. The apologists for municipal ownership are fain to disregard the failure of the generating plants, and to object to these cities being included in such a list as this. The fact, however, remains that these cities, undertaking to manufacture and sell electricity, have found it more economical to turn over to private enterprise the manufacturing end of the business, and to become mere retailers of the product. This is, of course, due to the fact that it is in the generating department that the greatest difficulties are encountered, and it is also there that the failure of municipalities to keep pace with the improvements in the art are most evident. Such cases afford, therefore, the strongest evidence that city officials whose own money is not invested in the business, and whose fortunes do not depend upon its maintaining a high degree of efficiency, are very unlikely to show the business push and initiative which are characteristic of private enterprise, and which

alone in these days of rapid progress can enable a business to maintain itself in the face of actual or potential competition. . . . . . Dr. Humphreys.

"The list which follows is by no means a complete representation of the failure of municipal ownership in this field, for it does not take into account those cases where cities are avowedly anxious to dispose of their plants, but where no customer has yet been found, nor those cities where a sale of the plants has been ordered by popular vote, but where the city councils, for reasons obvious to practical politicians, have refused to carry out the popular demand to be relieved of the burden. Nor does it take into account the far larger number of cases where the plants would be for sale if the citizens were not deceived by reports in which, by a suppression of many of the factors of cost, a profit is made to appear where there is an actual annual deficit. It is frequently only when the plant actually breaks down through a lack of the necessary expenditures for a proper upkeep, or when the tax rate increases abnormally, that the citizens wake to the fact that their chosen representatives have been keeping them in ignorance for reasons of their own. It should, however, in fairness be said that in some cases at least these misleading reports are due not to any deliberate intention on the part of city officials, but to the inevitable ignorance of men who are suddenly called upon to supervise for a short period the operation of a complicated business in which they have had no training or experience. It is, however, probably well within the facts to say that if the real conditions of the extant municipal lighting plants of this country were shown, a very large proportion of them would immediately be placed upon the market".

The descriptive matter, much of it prepared from public documents, throws a strong light upon the municipal ownership question, and should be welcomed by all who are not determined to remain in the dark with respect to this important question. Here we have the record of many experiences, many sad experiences, to put against the theories of inexperienced doctrinaires.

Referring to Mr. Ransom's opinion that he was extreme in his views, he desired to say that Mr. Ransom was referring more especially to San Francisco and to the problems of fire-department operations.

He was not, however, confining his study to San Francisco, and if the conditions in San Francisco were not as they should be, he might, out of courtesy, have omitted to refer to such a home case. He believed that the paper gives Mr. Ransom no warrant for saying that the author assumes "that the operation of public utilities is for the purpose of money making entirely". No more partial criticism of the paper could be made. The author does hold, however, that the money side of the question is necessarily involved, for here comes in the question of Trusteeship, and in the management of our cities the sense of responsibility with regard to Trusteeship has too often not been in existence. There are, as Mr. Ransom says, "larger questions than those of mere profit at stake, such as the duty of the citizens, and the public welfare".

Dr. Humphreys. But this duty and this welfare are necessarily involved in the expenditure of the moneys collected from the tax-payers.

He particularly agreed with Mr. Ransom in the view that the cities of the United States are not prepared to undertake municipal ownership. As to there being no precedent, if Mr. Ransom will study the report from which the author quotes and the other data available, he will find sufficient in the way of precedent and recorded experience. Specific reference might be made to ''The Dangers of Municipal Trading'' by Robert P. Porher, Director of the Eleventh U. S. Census.

He further agreed with Mr. Ransom in the view that one of the strongest objections to municipal ownership of public utilities is that frequently the cost is not levied on those it benefits the most. Is not this a ''community question''; and should a specific service rendered to certain members of the community be paid for by other members of the community who do not want or cannot avail themselves of the service? Is not this a question of ''money making'' on the part of one portion of the community at the expense of another portion?

Replying to Mr. Dimock, and with reference to his charge that the author holds ''extreme reactionary views'', he desired to get away from catchwords and consider definitions, thus:

''Reactionary: one who favors or promotes reaction; specifically, one who endeavors to check, undo, or reverse political progress''.

''Reaction—in politics, tendency toward a state of things which previously existed, as after revolution, reform, etc''.

Political progress is not necessarily along the line of the greatest good for the people as a whole. The history of the world shows that many so-called reforms had to be reformed backwards ''toward a state of things which previously existed''. The French Revolution is an extreme case under the definition. It is the tendency of mankind in trying to correct one evil to go to the other extreme. In the sense that the author believes in preserving and conserving all that is found by experience to be good in government and community life, and only to reject that for which we have a better substitute, he is a reactionary.

Mr. Dimock says ''the modern tendency is toward municipal ownership''. That requires proof. There are many working for this cause and many working against it, but Mr. Dimock's statement is not proof. As to comparison of the costs of service between municipal plants and private plants, that is a large question and cannot be settled by the statements issued by the municipalities, statements which notoriously are not complete or self-explanatory.

He quite agreed with Mr. Dimock in the statement that ''When the point is reached where the money of the people can be saved by municipal ownership it is high time that such system be adopted''. Mr. Dimock and the author evidently disagree from Mr. Ransom as to ''money making'' being something not to be considered when we think in community terms. The difference between Mr. Dimock and the author in this connection is that experience in the analysis of financial

data has convinced the author that, as a general proposition, rare cases perhaps to be excepted, the "high time" for the people to save money by adopting municipal ownership has not arrived and probably never will arrive under a government by the people. Dr. Humphreys.

Replying to Mr. Vensano, he agreed with him in regard to the danger in connection with municipal ownership of poor officials and instability of government. He was not sure that there is a "main advantage" or any other degree of advantage in "the ability of a city to borrow money more cheaply". Even if it be true, it does not follow that this advantage would be retained if the cities went in for municipal ownership. Personally he believed that the advantage, if it now exists, would disappear. During the last year or two we have seen many of our preconceptions in regard to money rates overturned. This is not only true of the countries now at war, but of many of the cities of the United States. There is such a thing as a city going into bankruptcy. Many corporations now enjoying a healthy existence would have gone into bankruptcy if they had followed the financial methods, including accountancy, of some of our important cities.

Replying to Mr. Rommel, he agreed that conditions would be greatly improved in many particulars if a non-partisan commission government could be secured and retained. But the elimination of partisanship does not necessarily ensure wise, honest, and efficient management. With regard to the greater opportunities for "technically trained engineers", the author argues in the paper for putting on each commission "at least one well-trained, experienced, open-minded, fair and courageous engineer". It by no means follows that because an engineer is "technically trained" he is qualified "to fill positions of responsibility in the administration of public utilities under public ownership", or in any other position. The specification as to qualification needs to be much broader than "technically trained".

Replying to Mr. Schuchardt, he desired to say that whether it is true or not that "no common ground can be reached on the discussion of the subject of municipal or private ownership", it certainly is true that it has been difficult to find that ground. It might be found if the advocates of municipal ownership could first be brought to concede that each municipally-owned tub, the same as each privately-owned tub, should be made to stand upon its own bottom. Thus would the "citizens be brought to a closer knowledge and interest in the government". The private corporations if wisely managed, will give the greatest measure of service for the smallest rate of compensation, and this for selfish if for no other reasons. This does not hold true in the case of utilities under political control.

Replying to Mr. Holcomb, he desired to point out that public welfare, sooner or later, is involved in the questions of revenue and taxes. The case cited in connection with the retention of franchise rights by a private corporation he believed to be at present an exceptional case, as it should be.

Dr. Humphreys.

The author felt under obligations to those who had taken the trouble to discuss his paper, for it is only by the frank expression of opinions, for and against the propositions advanced, that sound practice is developed, and he therefore regretted that the parts of the paper which treat of questions outside of municipal ownership or control received no attention in the discussion. Some of the questions so left untouched are vital to the health and prosperity of our country.

Paper No. 70

SHORT PAPER ON PUBLIC UTILITIES.

By

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F. S. I., M. R. San. I., F. R. S. A.
Chiswick, England

My first duty is to thank the Committee for the honour conferred in asking me to submit a paper on this important subject, and had not the War intervened, I would have obtained more statistical information which would have supported my opinions under the several headings.

Unfortunately, temporary losses through some of my Staff joining the Forces, and an increase in personal honorary duties, necessitated by the War, have necessarily limited my opportunities of including all I intended when I accepted the offer to present this paper.

The term "utilities" is not one in common use in England, but from the municipal engineering standpoint it appears that the following subjects might reasonably be included therein:

(1) Fire—Prevention, Protection, and Extinction.
(2) Provision of Public Parks and Pleasure Grounds.
(3) Housing of the Working Classes.
(4) Hospitals, Asylums, Prisons, etc.
(5) Water Supply and Provision of Food.
(6) Public Lighting by means of Gas, Electricity, etc.
(7) Means of External Transit, including Tramways, Motor Omnibusses, and Horse Vehicles, also Bridges and Piers for Public Waterways, etc.
(8) Public Baths and Wash-houses.
(9) Educational Institutions—Public Libraries, Museums, etc.
(10) Provision of Amusements, including Bands, Concerts, Cinematograph Shows, etc.
(11) Markets.

FIRE—PREVENTION, PROTECTION AND EXTINCTION.

The prevention of fire is somewhat more than an ordinary "utility", since it should be deemed an absolute necessity, but the Municipal Engineer is only concerned with the same to the extent of providing efficient building regulations and seeing that these are rigidly adhered to. Such regulations are still more important where materials of an inflammable, combustible, or explosive nature are manufactured; and therefore too much care cannot be taken to eliminate the causes of fire, since by that means prevention is secured.

The term "protection from fire" is closely allied to the foregoing, but operates when the former fails. Protection applies to goods as well as to human beings, and appliances for same may be fixed or movable.

Fixed appliances may include sufficient means of easy exit suitably protected by special, non-inflammable materials, and by the use of fire-resisting materials, including furniture and decorations. Protection may also include means of escape in the shape of ladders, canvas sheets, etc., but these latter should always be under the control of responsible persons.

Means for extinction of fires are closely allied to protection, and include automatic water-sprinkler installations, with suitable alarm attachments.

The public means of extinction should always be maintained at the highest possible state of efficiency, and include the latest types of high-power motor pumps and vehicles, with hose towers and other means of coping with fires in buildings of considerable height.

It is also desirable that chemical appliances should be carried, for first aid purposes, on light motor tenders, since often large conflagrations can be averted by the use of these small compact appliances. In the Author's opinion there is no question as to the absolute importance of the whole of the foregoing being under the sole control of the municipality.

PROVISION OF PUBLIC PARKS AND PLEASURE GROUNDS.

In the old country, the tendency in the past was for parks and all open spaces, except commons, to be provided by the wealthier classes, allowing the public the free use of such parks

attached to many of the fine, old English country homes; but during the last few decades the tendency, in towns of all sizes, has been to increase and multiply at the expense of the municipality recreation and pleasure grounds, solely available for the use of the public.

In addition to the foregoing, there are now throughout England many pleasure grounds maintained solely by private companies, and these are mostly available for certain kinds of sport, principally football, cricket and golf.

Certain municipalities have always striven to provide the ratepayers of their particular area with the best accommodation, as nearly as possible on similar lines to that obtained by the middle and upper classes on payment of somewhat high subscriptions, and there is a tendency to increase this practise at the public expense.

The Author is of opinion that open spaces or "lungs" should be provided solely at the cost of the ratepayers, but he is not in sympathy with sport being chargeable solely to them, beyond the elementary educational period, since the burden of taxation and local rating is already so great that the man who prefers walking should be allowed to walk without being required to pay for another man's golf.

The Author is not antagonistic to municipal golf or other pleasure grounds, provided that all items of sport are dealt with under the principle that each particular sport should be more or less self-supporting.

HOUSING OF THE WORKING CLASSES.

The problem of housing by the municipality, as opposed to private enterprise, is one that has probably caused more discussion than any other municipal problem.

Housing essentially appears to be a matter that can well be provided by private enterprise; and whilst there may at times be especial reasons for the municipality undertaking housing schemes in areas which may be already covered with the lowest class of slum property, the Author cannot see that the provision of houses for the working classes should necessarily become part of the routine work of the municipality.

Building is an industry, and the erection of buildings on

proper lines, if designed with every thought and consideration for economy and utility, should always prove a reasonable investment, except in the most costly areas.

In the Author's opinion, therefore, this reason alone should deter public authorities from undertaking housing schemes on any extensive scale, except in the foregoing, or, possibly, in certain other cases where the cost of purchasing property would render the same an unremunerative investment to private speculators.

HOSPITALS, ASYLUMS, PRISONS, ETC.

The provision of these important institutions, which deal with mental and physical infirmities, is essentially one which should be maintained out of the public purse, since none of the objects for which these particular institutions are provided are likely to be profitable undertakings from a pecuniary point of view.

Hospitals are needed for the proper treatment of those suffering from physical infirmities, and every appliance and the most modern methods of treatment should be available for use therein.

Asylums are necessitated by the lack of mental balance, which is, unfortunately, at times due to causes over which the individual may have no control, but which is often caused by the sins or misfortunes of the parents; and here also, bearing in mind that the sufferers are proportionately greater from the poorer classes, it becomes imperative for the institution to be maintained by the public.

Prisons, reformatories, etc., are needed to restore, if possible, the moral balance which has failed the individual in times of temptation; and the argument referred to for physical and mental ailments is equally applicable to prisons, etc.

The above are, therefore, essentially "utilities" which should be either municipal or national, and personally the Author is of opinion that the municipal expenditure should be superseded by a wholly national charge for this "utility".

WATER SUPPLY AND PROVISION OF FOOD.

In England, a few years ago the water supply was principally in the hands of private companies, and such provision

was not without its advantages, since Parliament safeguarded the consumer so far as his necessary rights were concerned, and it was in the interests of the company to afford an efficient supply of water at a reasonable rate.

Supplies are usually effected on a sliding scale, but for many years in the Metropolis the provision of water for public authorities was dealt with by eight authorised Public Companies, at a fixed rate per thousand gallons, irrespective of quantity.

The importance of unification was so apparent in a city like London that municipalisation and centralisation seemed absolutely essential to economy, and, therefore, practically the largest water undertaking in the world was formed under the title of "The Metropolitan Water Board".

This important body now controls the whole of the London water supply; and although in the early stages the cost to consumers in many cases appeared to be, and in fact was, unduly large owing to the enhanced initial expenditure in purchasing wealthy companies, in pensioning many of the better paid officials, and in altering the methods of charging, there is every hope that as these pensions fall in and the capital cost is gradually discharged, the ultimate cost to the consumers will be considerably reduced, and a practical certainty of an ample water supply be assured.

There is, also, another important advantage in this huge combination; since under the old régime shortages of water occurred in some districts in times of drought, whilst under the improved conditions of organisation, under a central authority, the entire linking up of mains has permanently avoided any similar prospect of shortage in the future.

It, therefore, seems to the Author that as water is a necessity and not a luxury, it is essentially a matter for good municipal control.

The provision of food stuffs other than milk or bread may lend itself to more competition if controlled by public companies, but the items above mentioned are clearly of such absolute importance to the welfare and health of the nation that the supply of these also lends itself to municipalisation.

It has been argued that meat should be treated in a similar

manner; but the Author is of opinion that if the slaughtering and storage of the same is properly undertaken in public abattoirs, the safety of the public should be sufficiently guaranteed, bearing in mind, also, that there is in every city and town a staff of qualified meat inspectors.

PUBLIC LIGHTING BY MEANS OF GAS, ELECTRICITY, ETC.

The provision of efficient lighting is at the present time considered a necessity, and if only one method of providing the same were available, it would seem desirable to municipalise such undertaking; but this not being the case, it is a moot point whether better results are not obtained by competition than by municipalisation. On the other hand, the provision of electricity works and gas works has already been undertaken by some local authorities in this country, with unparalleled success; and in some districts not only has the price to the consumers been largely reduced, but, in addition, profits have accrued to such an extent that the rating of the district has been materially benefited thereby.

This question of rating relief is undoubtedly open to abuse, and the Author is not wholly in sympathy with indiscriminate municipalisation of this "utility". At the same time, if a company has already obtained very full powers for either of the above undertakings and is not reducing charges proportionate to its profit-earning capacity, it is a matter which should receive the very careful consideration of the Municipal Council, as to whether the continuance of the company should be allowed, or the "utility" be purchased by the local authority.

The charges are sometimes met by sliding scales, which permit of an increased dividend to shareholders in a much smaller ratio than the decreased cost to the consumer, and if the undertaking is carefully controlled in this manner, the Author would not necessarily suggest that municipalisation is essential.

MEANS OF EXTERNAL TRANSIT

In these modern days, transit facilities are of the utmost importance, and long distance traveling is efficiently provided for by railway companies; but it does appear to the Author

that public traction or conveyance companies should not have unlimited powers in regard to the use of public highways for passenger or parcel carrying purposes.

The provision of tramway lines in the public highway is at the present time a burning question, and many highway engineers are of the opinion that their period of life is gradually drawing to a close. It is, of course, obvious that the motor omnibus has come to stay; and it is equally clear that its advantages over the tramway system in the event of breakdown are manifold, since a tramway breakdown at the generating station may temporarily disorganise the whole system, and even a single car breakdown may hold up all cars in an important area, whereas the breakdown of a self-propelled vehicle is limited solely to delaying the number of persons it can carry, and these, with proper organisation, are easily accommodated on other vehicles. The Author is, therefore, personally of the opinion that the motor omnibus or a similar vehicle has a great future, whilst tramways will be largely relegated to extra urban and rural traffic, in lieu of being used for interurban connections.

Organised municipal transit by means of horse traction has practically ceased to exist as a factor of city or urban transit, but the Author is of opinion that the need for the smaller vehicle will remain a necessity in the country as a feeder to the large trams and omnibusses for many years to come.

The provision of bridges for public waterways has nearly always been thrown upon the nation or the municipality, where such waterway is a natural river; but where the waterway is artificial, the company owning such canal or river is made responsible for the provision of an efficient and effective means of crossing the same at suitable intervals.

Piers or jetties in the larger public waterways or at seaside resorts are often a great asset to the municipality; and whilst it is sometimes difficult to get ratepayers to realize this in its initial stage, it has been found in some cases where the municipality has purchased or erected piers, etc., that the income from the same is considerably in excess of the interest and sinking-fund charge on the capital cost, together with general maintenance expenses. Whilst their provision is not nec-

essarily thrown upon the municipality, and is often made through private enterprise, the Author is of opinion that there is a very large future for this type of municipal "utility".

PUBLIC BATHS AND WASH-HOUSES.

The provision of public baths and wash-houses is seldom undertaken in this country by private enterprise, since it is only in certain districts, of a somewhat exceptional character, that the same are self-supporting. The foregoing applies to baths and wash-houses of the enclosed type.

In recent years, the provision of open air baths has considerably increased, and the Author's experience is that, with careful administration, in most cases this type of swimming bath can be and is made self-supporting, since the capital expenditure and capital charges are largely reduced below those necessary for the enclosed and covered type.

At the same time, the importance of facilities for swimming is so great and the need of washing facilities in the poorer districts is so important, as an element for fighting disease, that the municipality should undoubtedly undertake the provision of both these "utilities".

EDUCATIONAL INSTITUTIONS, PUBLIC LIBRARIES, MUSEUMS, ETC.

The education of the child is essentially a matter for the State, but under recent legislation in England, the Government has deputed to local authorities the task of administrating the Education Acts. This is effected by means of a Statutory Committee, formed usually with two-thirds Councillors and one-third co-opted members, the object of these latter being to introduce an outside educational element into the committee.

The result of this municipal organisation, which applies to large urban districts, burroughs and counties, is to make the provision of schools, play-grounds, and facilities for healthy exercise largely a municipal matter, and the Author therefore felt justified in including it under the head of municipal "utilities".

A large portion of the expenditure is met, at the present time, in most districts by the municipality, but this undoubt-

edly appears wrong in principle, since, as already stated, the education of the child should be solely a matter for the State.

It is hoped that subsequent legislation will minimise the local expenditure and increase that of the State in connection with educational matters.

Under this heading may be included public libraries, museums, etc. These are essentially of an educational character, but they are again dealt with by the municipality, in this instance exclusive of State assistance, as a rule.

Under the Public Libraries Acts in England, unless specially amended by Private Acts, a "one penny" rate may be collected for creating and fostering their growth, and it is surprising what advantages can accrue from such a small expenditure. Some of the larger cities have obtained Parliamentary powers to increase the above rate, and also provide for museums and public collections in a similar manner, except that it is usual for some munificent donor to provide the museum or its contents in the first instance.

All of these institutions are, of necessity, of such a public character as to eliminate private enterprise, but often call for and are benefited by private philanthropy.

PROVISION OF AMUSEMENTS, ETC.

This class of "utility" as applied to municipalities is of comparatively recent growth.

Under the old Public Health Acts, the provision of bands, etc., was not allowed out of public funds, but this has fortunately been amended by numerous Private Acts and by the most recent important amending Public Health Act.

In some seaside resorts which are very largely attended by visitors, the result of properly organised bands, concerts, etc., have actually proved a financial advantage, whilst the moral and educational advantages to the individual and the indirect financial advantage to residents prove that such "utilities" can, when properly organised, become of inestimable benefit to the locality.

The Author considers that the cinematograph may also lend itself to adoption by local authorities, where not properly administered by private enterprise. In principle, he considers,

as a general rule, that this particular type of show should be conducted as a trading concern and not by the municipality; but he understands that in one case a cinematograph has been unsuccessful when organised privately, but ultimately became successful when conducted by the local authority.

MARKETS.

The Author has not had much personal experience in connection with the administration of municipal markets, but, from observations, he is of opinion that their provision requires the most careful consideration.

In the larger towns there is little doubt that, given suitable positions and proper organisation, markets can be made self-supporting, and have been, at times, even a source of profit, whilst the advantages of inspection in a limited area tend to promote more care in the selection, handling, and sale of food-stuffs.

If, however, there is no ancient market and there is no special product or call for facilities for the convenience of the surrounding villages, it is probable that a good market would not be self-supporting for many years.

CONCLUSION.

In the foregoing notes the Author has refrained from giving and analysing any statistical information, partly owing to lack of time, and partly to the limits set by the Committee upon the length of papers, but he has appended tables which give some indication of the profits that can be obtained when "utilities" are dealt with by capable Councils advised by efficient municipal engineers.

TABLE I.

Extract from Board of Trade Returns for Tramways and Light Railways 1912-14 including Profits of Undertaking worked by Local Authorities.

	1912-13	1913-14
Miles of route opened............	2,661.69	2,702.83
Total number of passengers carried.	3,219,857,293	3,426,473,192
Number of miles run by cars......	334,777,515	354,379,672
Capital expenditure per mile of single track open—		
Lines and work..............	£13,726	£13,779
All items	£18,229	£18,332
Percentage of net receipts to total capital outlay	7.04	6.95
Percentage to net capital outlay (eliminating amounts expended on construction or purchase of old lines and works now superseded)	7.64	7.54
Percentage of working expenditure to gross receipts.............	62.68	64.35
Passengers carried per mile of route open	1,204,011	1,267,738
Passengers carried per car mile....	9.62	9.67
Average receipts per passenger.....	1.065d	1.053d
Amount paid in relief of rates out of profits of undertakings worked by local authorities..........	£544,478	£589,886

TABLE II.

Profits, where over £10,000, from Municipal Undertakings, etc., by which Rates levied in various Towns have been reduced. Estimated for 1914-15.

Town	Markets £	Gas £	Water £	Electric Light £	Tramways £	Estates Owned £	Other Sources £	Total Profits £	Amount in £ by which Rates Decreased S.	D.
Bath	67	*	1,500	....	*	11,750	....	13,317	0	8½
Belfast	3,610	21,400	....	5,000	10,000	....	....	40,010	0	7
Birkenhead	257	13,320	....	1,000	....	....	....	14,577	0	4¼
Birmingham	4,947	73,286	....	25,000	45,000	....	....	148,233	0	9½
Blackburn	3,984	....	4,000	3,000	2,000	....	....	12,984	0	6¼
Blackpool	1,800	4,700	....	3,000	12,000	....	....	21,500	0	9½
Bolton	1,700	21,000	†	....	17,000	1,771	3,221	44,692	1	1½
Bradford	4,000	5,000	10,000	5,000	10,000	....	24,200	58,200	0	9½
Bristol	2,464	....	....	....	....	23,419	....	25,883	0	3½
Burnley	1,570	4,470	....	5,971	10,000	....	....	22,011	1	1
Bury	246	2,500	....	1,000	5,000	....	2,558	11,304	0	10¼
Cardiff	....	....	....	....	9,600	9,000	....	18,600	0	4
Coventry	....	5,000	5,000	5,250	....	1,500	....	16,750	0	10
Croydon	....	....	12,038	....	....	....	550	12,588	0	3
Darlington	239	5,200	8,500	4,300	....	750	551	19,540	1	5
Dewsbury	500	9,700	1,449	....	....	....	....	11,649	0	11¼
Halifax	450	9,659	....	4,041	6,171	....	6,203	26,524	1	2½
Hull	3,325	†	15,000	†	7,000	20,000	3,000	48,325	0	9
Leeds	7,075	....	10,000	20,000	95,000	....	....	132,075	1	2½
Leicester	2,884	20,000	....	....	10,000	6,717	15,280	54,881	1	2⅛

Lincoln	....	5,500	....	1,500	....	3,115	945	11,060	0	10¾
Liverpool	16,213	....	....	25,000	100,000	84,686	....	225,899	1	1¾
Manchester	17,000	50,000	....	30,000	100,000	....	....	197,000	0	10¾
Newcastle-on-Tyne	7,039	....	....	....	18,000	13,980	....	39,019	0	6
Nottingham	6,616	30,455	....	8,000	24,000	15,483	....	84,544	1	6
Oldham	1,206	7,500	....	....	....	....	3,605	12,311	0	6
Oxford	1,553	....	6,387	....	....	6,060	....	14,000	0	8
Plymouth	1,207	....	7,359	539	2,978	3,678	....	15,761	0	6½
Portsmouth	233	*	*	3,000	5,000	270	4,215	12,718	0	2¾
Preston	4,510	*	....	*	‡3,750	5,890	3,300	17,450	0	9¾
Rockdale	....	5,454	....	....	3,489	....	6,874	15,817	0	10¼
Rotherham	700	6,725	....	6,350	750	....	....	14,525	1	4
Salford	....	12,090	4,000	....	22,000	....	1,045	39,135	0	10¼
Sheffield	....	*	†	†	27,910	....	....	27,910	0	3½
Southampton	242	....	....	†	‡5,060	3,228	4,500	13,030	0	5
Southend-on-Sea	....	1,500	....	2,000	9,500	....	2,538	15,538	0	6¾
Southport	1,000	14,000	....	....	....	....	....	15,000	0	7½
Stockport	217	12,000	....	3,000	15,250	400	577	31,444	1	2½
Swansea	2,345	....	....	2,200	3,000	11,321	....	18,866	0	8
Wallasey	....	14,500	4,750	....	8,000	....	....	27,250	1	1½
Walsall	600	6,000	....	....	2,000	1,400	....	10,000	0	10
Warrington	3,346	13,340	500	1,000	2,500	....	....	20,686	1	7½
Wolverhampton	3,705	....	4,251	2,125	5,554	....	....	15,635	0	10¾
Yarmouth	590	....	....	....	....	14,612	3,758	18,960	1	7

* Private Company.
† Profits to Reserve Fund.
‡ Additional Profits to Reserve.

DISCUSSION

Dr. Humphreys.

Dr. Alexander C. Humphreys,* Mem. Am. Soc. M. E. (by letter), thought that in view of the conditions and difficulties under which the Public Utilities of the United States are at present required to operate, it was opportune to have before us for comparison a paper reflecting conditions in Great Britain.

With regard to ''Fire—Prevention, Protection and Extinction,'' he agreed that this department should be ''under the sole control of the municipality''.

Referring to the section on ''Parks and Pleasure Grounds'', while he believes in open spaces or ''lungs'' to be provided by the taxpayers, he thought all of this work should be governed by common sense and a constant purpose not to make it too easy for people to get something for nothing. This easy acceptance of that which is not earned leads to trouble in many directions, particularly it leads to a lessening of the sense of responsibility. In this department, sentimentality should be controlled by common sense. We may say that this is a good rule for all departments within and without the municipal limits.

What he had said with regard to the last section, he thought could well be applied to the section on ''Housing of the Working Classes''. Don't supply, at the expense of the taxpayer, conveniences and facilities that the householder will not appreciate and will not protect from injury. Personally he holds that this class of undertaking is outside the province of the municipality.

Referring to the section on water supply, he felt that we may well call particular attention of our legislators to the statement made in regard to the taking over of the private water companies of London when it became expedient to bring them together under one municipal board. The owners were properly compensated for their property taken over. The author says—''Although in the early stages (under municipal control) the cost to consumers in many cases appeared to be, and in fact was, unduly large owing to the enhanced initial expenditure in purchasing wealthy companies, in pensioning many of the better paid officials, and in altering the methods of charging . . . . .'' The authorities nevertheless believed that an advantage would come to the inhabitants of the district as a whole by taking over the water supply. For this advantage they felt it was honest to pay what the property was worth to those who had risked their investment to develop these advantages later coveted by the authorities. This is in marked contrast to much of that which is done in this country under similar circumstances, where ''going-value'' is ignored or made little of and ''depreciation'' is magnified.

He agrees with the author that water is a necessity, therefore, it falls into a different class from gas, electric light, and transit facilities.

Dr. Humphreys says that he is not prepared to admit that the municipal operation of lighting plants has been demonstrated as an ''un-

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Dr. Humphreys.

paralleled success'' even in Great Britain. If the prices charged for service are to be compared with the prices charged by the private companies, the accounts must first be brought to the same standards. No help should be given to the municipal lighting undertaking through the tax levy. This is sometimes done when it does not appear on the surface. Full interest for the money invested and full allowance for the taxes which would have been collected from the private company and are therefore lost to the municipality should be brought into the comparison. The taxpayers as a whole should not be called upon to pay for advantages (not necessities), enjoyed by only a part of their number.

Referring to ''Means of External Transit, etc.'', he feels that if tramway companies should be limited as to their occupancy of public highways, then certainly the motor bus, which applies its wear to the pavements, should still more be limited as to free privilege. The tram car wears on the rail, which is renewed at the company's expense.

Here is a question which must be settled in connection with the introduction of the ''jitney'', now coming so much into evidence. If the tram cars (trolleys) should pay for their occupancy of the streets, certainly the ''jitneys'' should, when they are so destructive of many of the kinds of pavements now in use.

Regarding ''Educational Institutions'' he expressed interest in reading the argument in favor of placing upon the ''State'' (Nation), instead of upon the municipality, the cost of educating the children of the country.

In the United States the cost is borne by the local authorities and the State authorities. The details vary in the several States, and vary quite widely. Much might be said for and against Mr. Willis' contention if applied to this country.

We may at least hope if the Federal authorities should be permitted to undertake this job that they would do better as to efficiency and economy than is now being done by many of the local boards. But this is a change that hardly could be fitted in with our form of government, though much more could be done by the Federal authorities in the way of wise co-operation with the local authorities—municipal and State—than is now being done.

Dr. Humphreys expresses himself as being, in general, firm in the belief that people are the best governed who are governed the least. The aim of those in authority should be to do their utmost to cultivate in the people a desire to govern themselves wisely.

Any policy which tends to reduce individual initiative must weaken eventually those who are thus over-cared for.

While he has great admiration for much that is found in the public life of Great Britain, he fears that of late years the tendency has been to soften the people by an excess of sentimentality in the reform movements.

Water [illegible]

2 1. [illegible]

1 2. [illegible]

3. [illegible]

4. [illegible] [illegible]

[illegible]

5. [illegible]

[illegible]

1. [illegible]

2. [illegible]

1. [illegible]

2. [illegible]

[illegible]

[illegible]

Loss of Water by

1. Leakage from mains

2. " [illegible]

[illegible]

The Protection

[illegible]

1. [illegible]

2. Purification from Pollution

3. [illegible]

4. Avoidance of Waste.

No of germs per C.C. Centimetre should not exceed 100

13 Gallons per day per head for potable water
40 " " " " " " ordinary "

Protection of source of supply

<u>Distribution Reservoir</u>

1. should be easily cleaned, 2 compartments necessary
Flushing + drainage of distributing pipes
Chemical analysis at regular intervals
Bacteriological examination — do   Colon Bacillus